BULLETIN

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AND

THE PHYSICAL SOCIETY

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(*revised advertisement*)

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Proceedings of the International Conference on Physics Education

Organized under the auspices of the International Union of Pure and Applied Physics

Held at UNESCO House, Paris,
July 18th—August 4th, 1960

Edited by SANBORN C. BROWN,
Associate Professor of Physics, M.I.T.
and NORMAN CLARKE,
Deputy Secretary, The Institute of Physics and The Physical Society, London.

A collection and assessment of the facts, opinion, and ideas exchanged during the conference, this book looks at the problem of physics education as a whole. It deals with physics education from grammar school to postgraduate training in the light of education systems found in the major countries of the world.

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BULLETIN
OF
THE INSTITUTE OF PHYSICS
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MAY, 1961

The Development and the Future of Physics

SIR JOHN COCKCROFT
O.M., K.C.B., C.B.E., D.Sc., F.Inst.P., F.R.S., *Nobel Laureate*

[The Presidential Address given in London on May 2, 1961]

THE COUNCIL of our Institute and Society have decided that in future the President will be asked to do somewhat more work than some of his predecessors by giving an Address to our assembled members, on or about the time of the anniversary of the incorporation of the amalgamated body in May.

During the last year we have brought into effect the long-sought-for amalgamation of The Institute of Physics and The Physical Society and I think that everyone will agree that the union has so far been quite harmonious, so much so that we should now be able to forget our separate origins and, perhaps, even change our clumsy title to one or another of the twenty simpler titles that have been suggested by members.

Since our formation our total membership (including students and subscribers) has grown from 8450 to 8850; our full Members have increased from 6850 to 7250 and it seems likely that we can expect a growth rate of the order of 8% per annum, judging by the rate of increase of professional physicists in the country as a whole. So our successors on the Council may, in the course of the next 10 years, be faced with a difficult accommodation problem. Members will know that the Council considered this problem seriously and decided that for the next five years or so we should try to carry on our work by making use of both the House in Belgrave Square and the old offices of The Physical Society in South Kensington where our tenure has been very kindly prolonged by The Royal Commissioners for the Exhibition of 1851. This has enabled us to concentrate our editorial work at Lowther Gardens, leaving the Belgrave Square House as headquarters and to provide for the remainder of our activities including the distribution of the publications. The rapid growth of all our work may, however, necessitate an earlier review of the position. Our present principal deficiency is the lack of a lecture room to hold more than eighty so that all large meetings have to be held in the meeting rooms of sister bodies or in College lecture theatres.

The Council were also faced with the problem of balancing our budget and leaving a little over. We decided that it was very desirable to increase our income during the next seven years by about £20,000 per annum. to enable us to continue and to expand slightly our scientific and educational work to meet some of the growing demands made to us for help, and to enable more of the income from the publications to be used for their improvement. The appeal which we launched in the autumn has, I am glad to say, done very well and we have received or been promised so far a total sum of over £112,000. This success is due to the Treasurer and his colleagues and we are all most grateful to them. We asked our members in the United Kingdom to make a modest contribution—of the order of £1 per annum for a period of seven years. So far only about 500 of the members asked (i.e. about 10%) have responded and the Treasurer is still expecting to hear from the remainder. I hope that he will not be disappointed.

Since October the scientific meetings of the Institute and Society have, as in the past, been very numerous and about 150 have been arranged for the 1960/61 session in London, the provinces and in Scotland and Wales; our Australian branch has also arranged many meetings. They have included or will have included six residential conferences on various aspects of nuclear and solid state physics, symposia, papers and discussions on most of the branches of physics in which research work is being carried out at present and on educational topics such as the teaching of mathematical physics. Nor have we forgotten the more cultural aspects ; Fellows have read papers on " The physics of painting ", and on " A physicist looks at music ".

During the year the Council has made the following awards of distinction: The Duddell Medal to Dr. J. B. Adams, the C.V. Boys' Prize to Professor A. W. Merrison, the Charles Chree Medal and Prize to Dr. S. E. Forbush and the Council has appointed Dr. D. Shoenberg as Guthrie Lecturer and Dr. H. H. Hopkins as the Thomas Young Orator. I should like to congratulate all our medallists and lecturers.

I will now speak about the development and prospects of physics looking a little into the crystal ball to see where the developments we now know about may lead us.

Looking first of all at the overall numbers of professional physicists in the country, the numbers in 1959 were estimated by the Scientific Manpower Committee of the Advisory Council on Scientific Policy to be about 14,000 and likely to grow to 17,500 by 1962, a growth rate of about 8% per annum. So we physicists now comprise about 23% of the total qualified scientists in the country —the engineers being counted separately. If we were to use the standards required by the Institute and Society to define a professional physicist the overall number of physicists would be about 30% lower.

Of the present numbers, about 6,000 are employed in education and about 5,500 in manufacturing industry. Government service and nationalised industries account for the remainder.

This steadily increasing requirement for physicists is being fed by university output of about 860 a year graduating with honours in physics, including mathematical physics and, in Scotland, recognized honours courses combining mathematics and physics. These numbers would not be sufficient to achieve the required growth-rate when account is taken of wastage, were it not for the fact that the number of physicists entering the universities is increasing rapidly. Thus in Cambridge the number of students taking Part II physics is now about 100 annually, and the number taking the Final Honours Physics year in Oxford is now about 150, whilst the University of London has about 300 third year students of physics. The total entrants to honours physics courses in all universities is now around 1,500 annually.

The developments responsible for the increasing demand for physicists in industry are very numerous. The electrical and electronic industries now employ perhaps 4,000 physicists. Many of these are engaged in solid state physics. Dr. John Fisher, in an article in *Science* two years ago, estimated from a study of world literature that there were then about 10,000 scientists working in industry on solid state physics. Of these 24% were working in the U.S.S.R., 21% in the U.S., 11% in the U.K. and 10% in Japan. The number had increased 2½ times in seven years. This effort had, in the United States, resulted in an output valued at 500 million dollars in 1960, and this had been doubling every two years of the previous decade.

The development of the transistor since its discovery in the Bell Telephone Laboratories in 1948 had been a powerful contribution to this growth. The transistor had been very attractive to the electronics industry, the principle advantage being small size, high efficiency and high reliability. These features are particularly important where large numbers of components have to be used, for instance in digital computers, communications equipment and in certain industrial control systems. The obvious attraction of the transistor to domestic radio applications has also helped to bring about a large-scale production of transistors. Development of transistors continues apace, particularly in the direction of high-frequency amplification and high-speed switching. Most of the work is on germanium and silicon transistors; germanium is more attractive when designing high-frequency transistors whereas transistors made of silicon can withstand higher temperatures. The transistor has led to a great reduction in the size of electronic equipment. This trend towards small size, often coupled with greater reliability, is continuing as the electronic components industry tends to make groups of components, possibly complete circuits, rather than individual components. One can foresee complete circuits, including transistors, being made in the component manufacturers' factory.

Tunnel diodes are expected to play an important part in very-high-speed computers; they can also be used as amplifiers and oscillators at very high frequencies and are expected to compete with and to complement transistors. The chief materials for tunnel diode work are germanium and gallium arsenide, the latter offering the possibility of operation at frequencies of 10,000 Mc/s or higher. The use of tunnel diodes as two-state storage and logical elements for high-speed digital computers has received a good deal of study, as well as their use in amplifiers. The fact that the tunnel diode is a two-terminal device and that the resultant circuits are bi-directional is a serious disadvantage which, while not insuperable, leads to complication and, in the case of amplifiers, difficulty in obtaining stable amplification, free from oscillation. Tunnel-diode computing logical circuits so far reported are no faster than those using fast transistors, and they demand great stability and uniformity in the characteristic of the diodes and of the associated electronic components. Whether this can be counted on without introducing excessive manufacturing difficulties is not yet certain. It is, however, known that the tunnel diode is affected much less than the transistor by changes of temperature and by nuclear radiation.

As a circuit element the tunnel diode has unique properties. It appears, however, to be less versatile than the transistor and so presents challenging problems to the circuit designer.

Gallium arsenide is only one of the intermetallic compounds now being examined as possible materials for use in transistors, tunnel diodes and other electronic devices. One of the others is silicon carbide which could lead to components that can be used at temperatures much higher than silicon will withstand. The Hall effect in indium antimonide can be exploited to measure magnetic fields.

During the same period of 10 years we have seen the application of semiconductors to large-scale power applications through the use of the silicon power rectifier, and the controlled silicon power rectifier. These can now handle megawatts of power so that rotating machinery for conversion of a.c. to d.c. for magnets and similar supplies is now being replaced in the United States by controlled rectifiers providing a high degree of stabilization. The controlled rectifier, which can be likened to a thyratron in some respects, has a much lower voltage drop across it in its conducting state ; this, coupled with its very low switching time enables it to be used as an electronic contactor in medium-power a.c. and d.c. contactor circuits, high speed circuit breakers and d.c. to a.c. inverters.

We are also seeing the beginning of the use of semiconductors for the direct conversion of light to electricity. They are being used for obvious reasons in space research, the satellites being provided with large paddles and silicon diodes transforming radiation energy into electricity. The conversion efficiency is at present of the order of 8%, but is expected to rise to about 12% with development.

Allied to this is the use of semiconductors for refrigeration. This has been pursued in this country, the U.S.A. and the U.S.S.R. I understand that the performance of this type of refrigerator is still below that of compressor-built refrigerators by a factor of rather more than two.

A parallel attack on the direct conversion of heat to electricity is proceeding through the development of the caesium vapour diode in which a high temperature cathode boils off electrons whilst the caesium ions, by annulling space charge, allow high currents to pass through the diode. The conversion efficiency increases rapidly with cathode temperature and so far efficiencies of 17% have been reported with prospects of going up to 30%. Magneto-hydrodynamic generators which convert the energy of a gas at a temperature of 3000°C to electrical energy by passing the plasma through a powerful magnetic field are showing promise of high efficiencies and 200 kW of power has already been generated for short periods.

The fuel cell is another interesting energy conversion device at present in the early experimental stage. The fuel cell converts the chemical energy of gases such as oxygen and hydrogen directly into electricity and the theoretical efficiency can be as high as a 100%. So far efficiencies of about 70% have been realized with small scale equipment. Work has been proceeding on a small scale in this country supported by the National Research Development Corporation. One of the objectives is to make use of naturally available gases such as methane.

The successful development of fuel cells might well bring back electric automobiles into large scale use.

Development in electronic valves has proceeded steadily through the last decade. We now have, at the upper end of the power scale, klystrons which can develop 20 megawatts of power at 10 cm wavelength and sealed-off klystrons producing 6 megawatts of microwave power are now used in this country in electron linear accelerators used for radiation sources, nuclear physics, and radiation therapy, as well as for Band IV T.V. transmitters and v.h.f. scatter propagation transmitters.

These developments have made possible the Stanford 1000 million electron-volt linear accelerator using 24 klystrons as a power source, whilst a 50 BeV linear accelerator using correspondingly more klystrons is now awaiting Congressional approval or disapproval.

At the other end of the power scale we have the very sensitive maser receivers which depend on the balance of electron population in energy-states of crystals. These normally require cooling by liquid helium but this is not too difficult nowadays with the advent of the commercial type helium liquifiers. These receiving devices can now detect as little as $2{\cdot}5 \times 10^{-16}$ W/Mc and can provide substantial amplification at 10,000 Mc/s. They are being used by radioastronomers who need to increase to the limit the power of detection of very faint radio sources at the boundary of the universe. Energy fluxes of the order of 10^{-30} watts per sq. cm are measurable, corresponding to source strengths of tens of thousands of megawatts in radio stars at a distance of six billion light years.

The Bell Laboratories have reported another interesting development of the maser principle in the facility of a ruby crystal to take in luminous energy, thereby raising electrons to excited states which on return to their normal states cause emission of coherent radiation in the red (at $0{\cdot}64\mu$) as a very intense narrow beam. This is made possible by the optical properties of the ruby crystal when the ends are made optically parallel.

Low temperature physics may have another practical application in the use of superconducting films to act as a storage system for computers, the information being contained by the superconducting state of the film. There seems to be a real promise that very capacious memories could be obtained in a very small volume. The recent discovery that niobium alloys can retain superconductivity in fields of over 80000 gauss may reduce greatly the power required to produce very strong magnetic fields and this may affect the design of accelerators and much other equipment.

The ferrites are an example of the development of magnetic materials. Typical uses are for radiofrequency inductors, information storage in computers and the use of their gyromagnetic behaviour to form the basis of non-reciprocal devices at microwave frequencies, e.g., isolators and circulators in trunk radio. They have also been used for controlling the frequency of accelerating units in high energy proton-synchrotrons. The CERN proton-synchrotron frequency range of 3 MHz to 9·5 MHz is made possible by the use of ferrites.

Other interesting developments have been the production of artificial diamonds of industrial quality, a development which has been predicted as likely to lead to an industrial output worth over a hundred million dollars a year.

The applications of physics to communication systems is leading to important developments. The great success of the transatlantic cable for telephone traffic to North America is being followed up by the laying of cables to Australia and New Zealand and, as a result of research, the number of simultaneous conversations on a single cable seems likely to be raised to over 200. Electronic telephone exchanges will enable us to dial numbers in Europe and ultimately throughout the world. These have been made possible only by the use of transistors.

Atomic energy development has provided another major demand for physicists and the U.K.A.E.A. alone now employs about 1,000 professional physicists (*Scientific and Engineering Man Power in Great Britain 1959.* Command 902). These are distributed between the research establishments and the four major factories of the A.E.A., but the great majority are engaged in research and development work. At one end of the spectrum are the nuclear physicists engaged in determining nuclear data, such as cross-sections, with the increased precision which is now required. Closely associated with these are the reactor physicists, usually working on integral systems such as sub-critical assemblies and zero-energy reactors. Their objective is to predict from experiments on such systems over a wide temperature range the nuclear performance of full scale nuclear power stations. They have to take into account the effects of conversion of ^{235}U destroyed in fission to secondary plutonium built up in the fuel, and the consequent formation of fission products, and are particularly concerned with the effect of temperature changes. A particular example would be to predict how far the high temperature gas-cooled reactor, typified by the Dragon product at Winfrith Heath, could lead to a reactor which created more ^{233}U fuel than it consumed. Another important problem of the reactor physicist is to predict the kinetic behaviour of reactors—how they respond to small disturbances such as changes in blower speed—whether the disturbance if left uncorrected would grow with a doubling time of seconds, minutes or hours, and what this involves for the design of the control system. The small-scale investigations, aided by theoretical studies on fast computors, have so far given good agreement with full scale experiments carried out at Calder Hall, in which deliberate changes in operating conditions have been made and the results observed.

Another group of physicists is engaged on the important study of radiation damage. Radiation damage in graphite results from the displacement of carbon atoms to interstitial positions, and energy is stored and can reach hundreds of calories per gramme, making possible large spontaneous rises of temperature. It also results in growth or shrinkage of the graphite. Work carried out during the last few years had led to a good understanding of this phenomenon, and by operating the graphite at a high enough temperature—of the order of 220°C—the effects of radiation damage can be kept so small as not to affect the life of future reactors. Of even greater importance is the effect of radiation damage on nuclear fuel elements since this effectively limits the life of fuel elements and is, therefore, a determining factor in fuel costs. The work of physicists and metallurgists has made it possible to reduce the distortion of fuel elements to manageable proportions so that failure rates of less than five in 10,000 can be achieved and one of the Calder Hall reactors has, in consequence, recently achieved a record run of over a year without being shut down.

Another important group of physicists is engaged in plasma physics research with the long-term objective of producing power from fusion reactions. Experimental work with ZETA is elucidating the mechanisms by which a very hot plasma loses energy. Measurement of the Doppler broadening of several impurity lines has confirmed ion temperatures of about 5 million degrees. In California, ion temperatures of the order of 30 million degrees have been reported by Dr. Post, working with a double-stage plasma compression mirror machine, and at these temperatures and at the density of 10^{14} ions/cc the plasm remains stable. Results from a third compression are awaited. There has, through work in many laboratories, been some steady progress in our understanding of plasma physics, but controlled fusion research is likely to remain in the basic research stage for some considerable time yet.

Turning to other branches of the nationalized industries, the Electricity Council and Scottish Electricity Board employed about 39 physicists in 1959 and expect to increase this to about 113 by 1962, no doubt due to the commissioning of nuclear power stations. The National Coal Board, on the other hand, predicted no increase in the employment of physicists beyond the 134 employed in 1959. At the lower end of the scale the British Transport Commission employs only 15 physicists and to provide for its modernization programme expects to employ two more by 1962.

Government Departments, Research Councils and Research Associations between them employed about 1,800 physicists in 1956, of whom about 1,000 were employed by defence departments. These numbers include a large part of the professional staff of the National Physical Laboratory as well as the important groups working on electronics and radar in defence establishments, and the physicists working on aerodynamic research at the R.A.E.

The role of the universities is not only to provide the flow of young physicists to maintain and build up the number of physicists in industry and government service, but to provide a good part of the basic knowledge on which future applications of physics will be based. To achieve this we now have in the universities about 700 physicists in teaching posts and about 1,000 postgraduate students. We have therefore probably about 1,400 physicists doing research in the universities. This is none too many to provide a base for the great future applications of physics.

From information received by the Institute and Society of the work of 850 research students, these physicists are distributed amongst about six major fields of physics in the following proportions:—

	Percentage
Nuclear Physics and Cosmic Ray Physics	33
Solid State and Low Temperature Physics	28
Astronomy, Radio Astronomy and Space Research including Radio Physics	7
Bio-physics and Molecular Biology	Each about 2
Plasma Physics	
Geophysics	
Remainder	26

Professor Merrison has recently studied the distribution of 670 Ph.D. theses during the last five years.

These are:—

	Percentage
Nuclear Physics and Cosmic Ray Physics	34
Solid State and Low Temperature Physics	29
Spectroscopy, X-Ray Physics, X-Ray and Electron Diffraction, Nuclear and Electron Magnetic Resonance	14
Biophysics	1·4
Plasma Physics	4
Geophysics and Meteorology	2·2
Remainder	15·4

Nuclear physics, solid state physics and the various forms of space research take the lion's share of the physicists and seem likely to continue to do so for some time. The distribution of effort between nuclear physics and solid state physics is roughly the same as in industry and the Atomic Energy Authority. Effort in biophysics, molecular biology and geophysics is small. Professor Merrison's enquiry showed also that about 27% of the 170 Ph.D. physicists produced each year stay in universities. This is far too low to provide for the expected expansion of university physics departments in the next decade. About 20% of the Ph.D.'s go abroad.

High-energy nuclear physics continues to be one of the growing points of science. Recent results from Berkeley show that the family of 32 elementary particles is not a closed one, as had been thought a little time ago, and there is now good evidence for four new members of the family, so our powerful proton-synchrotrons are likely to have an important task in discovering new members of the family and we hope that, with this increasing knowledge, theoretical physicists may some day be able to explain why they have their particular masses and lifetimes and genetic relationships, and how these are related to the all-important nuclear forces.

The high-energy electron machines have a somewhat different role in exploring the structure of nucleons and searching for the point when electrodynamics may break down in very close collisions. The recent success at Frascati of producing, in a storage ring, electron-positron pairs of electrons from the radiation of the 1 BeV electron synchrotron and evidence that they are likely to circulate for very long periods, encourages us to hope that experiments with colliding beams of electrons will greatly increase the effective energy available for such experiments.

Proton-synchrotrons of 200/300 BeV can undoubtedly now be built, given the 200 million dollars or so required, and there is some discussion as to whether this should be a world-wide project or a co-operative project between the U.S. and U.S.S.R. with the Europeans giving a hand. The undoubted success of the CERN machine has fortunately made European technology in this field much respected.

Even such a machine could hardly compete with the 10^{14} electron-volt cosmic ray particles used by Professor Powell and others for the study of super-high-energy collisions, and still less with the 10^{18} electron-volt particles which produce the largest showers.

Studies of nuclear structure seem likely to have at least a 10 to 20 years further interesting life with the advent of the tandem and double-tandem electrostatic generators, enabling the potential barriers of the heaviest nuclei to be surmounted.

In the field of solid state and low temperature physics the classical low temperature physics, devoted primarily to the studies of superconductivity and the behaviour of liquid helium, seems to be working itself out, and low temperatures seem likely to become mainly a tool for work in solid state physics. Solid state physics seems likely to require other important tools such as electromagnets producing fields of 100,000-300,000 gauss for the splitting of energy-levels in solids. Electron microscopes are having an important role in showing the formation and behaviour of dislocations in solids, and ion emission microscopes are even making it possible to show individual atoms in a crystal, and the effects of radiation damage on the array.

Space research seems likely to outstrip nuclear physics research both in glamour and expense in the U.S. and U.S.S.R. We have recently been both interested and entertained by the measurement of the distribution in space of radio sources and the rival interpretations of their results. We look forward to even more powerful radio telescopes pushing the boundaries of the observable universe further and further away. We shall also perhaps learn from satellites whether the radio astronomers' determinations of the surface temperature of Venus and the Moon and other planets are borne out by more direct observations. And no doubt we shall learn much more about magnetic fields and particles in interplanetary space. It is very remarkable how the advent of rockets, with their prestige and military implications, has brought the once greatly neglected field of astronomy into the full limelight.

The military and disarmament interest in the detection of underground explosions has had a similar effect on the earth sciences and seismology in particular, and it seems likely that they will now get a little more support in this country. By contrast with British neglect, across the Atlantic M.I.T. is to have a new Earth Sciences Institute costing about six million dollars, whilst project Mohole, aiming at boring through the earth's crust to the underlying rock, has started experimental drillings, aiming ultimately at drilling through three miles of rock three miles below the surface of the ocean. In this task the oceanographic vessels of the Scripps Institute of Oceanography are to provide accommodation for a truly mixed team of geophysicists, meteorologists, microbiologists, palaeontologists, sedimentary petrologists and a doctor—a good illustration of the need for interdisciplinary studies in the earth sciences.

Molecular biology and biophysics, though employing few physicists at present, are already becoming of major importance. The achievement of the Cavendish Laboratory/M.R.C. Group in unravelling the structure of myogloblin with the help of X-ray technology and the EDSAC computer is a taste of things to come. They will, in the future, need much more powerful electronic and computing aids in order that their work shall develop as it should. The Crick-Watson double-helix model of D.N.A. derived from X-ray data of Wilkins shows what a powerful influence physicists can have on the development of biology where genetic coding is now a central problem.

I have said enough, perhaps, to show how very much alive fundamental research and physics are to-day. This liveliness is illustrated by suggestions the Council has recently received for adding to the ten specialist Groups new ones for space research, magnetism, and vacuum technology and by the requests we receive from distinguished physicists to undertake the preparation of reports on facilities for research, and on various aspects of the education and training of physicists.

The increasing scale of expenditure on physics research has led to important changes in the organization of high energy physics. The foundation of CERN enabled Western European physicists to build the remarkably successful 28 BeV proton-synchrotron which came into full experimental use six months earlier than had been anticipated and which exceeded its design performance by a handsome margin. Whilst we are naturally proud of the leadership of our Duddell Medallist, John Adams, and of the senior U.K. physicists who took part, the results owed a great deal to the fact that it was possible to draw on some of the best brains in Europe for this task so that the team as a whole was far more competent than could have been assembled in any individual country.

The pattern of use of the accelerator is extremely interesting. Bubble chambers and cloud chambers, large and small, are being constructed in individual countries and move to CERN where they are operated by mixed CERN and national teams, and the photographs obtained are distributed both to CERN-based physicists and to physicists in the member countries. In this country seven university groups will have equipped or are equipping themselves with apparatus of a standard design to do the examination of film in their own laboratories. In a similar way photographic plates exposed to the different beams of primary and secondary particles are analyzed in home laboratories. Throughout the development of CERN, Council Members have insisted on the importance of this unique tool being available for universities in all member and other countries, and not just limited to use by CERN staff.

To provide for this pattern of use the D.S.I.R. has made very substantial grants to university teams and to a consortium of U.K. universities to provide for equipment, assistance, travel and transport to enable full advantage to be taken of the accelerator.

The foundation of the National Institute for Research in Nuclear Science has provided a further important tool, the 50 MeV proton linear accelerator and the NIMROD 6-7 GeV high-intensity proton-synchrotron now being built to provide additional facilities for U.K. universities to work in the high-energy nuclear physics field. Already six universities are carrying out experiments on the proton linear accelerator and three more are planning experiments, and a number of universities are planning equipment and building equipment for NIMROD. NIMROD will make it possible for U.K. universities to do bubble chamber counter experiments with beams of primary and secondary particles, experiments such as those using K mesons for probing the structure of the nucleon or producing evidence for new strange particles. Physicists are unanimous that this centralization of large facilities should not go too far, and that it is essential to have some home based accelerators of less complexity and cost in universities where research students can get their initial training. Arrangements are now being made whereby expensive accelerators sited in a university are made available to other universities. Thus the Liverpool tandem Van de Graaf generator will be used also by Manchester University.

Similar problems of organization will arise in the use of powerful multi-million-pound computers and in radio-astronomy and other forms of space research. The number of such powerful tools will be very limited and it will be essential to make arrangements which will make it as easy as possible for universities and other research organizations to work with them on a co-operative basis.

The provision of these powerful tools is essential if we are to make the maximum possible use of our undoubted great scientific human resources and continue to hold our own in physical science with the American and the Russian big battalions. Our annual expenditure on basic physical research to-day is probably of the order of £10 million, excluding university staff salaries and expenditure on buildings. This will certainly need to be doubled and redoubled over the next ten years to provide for the increased number of research students and the expensive and important new developments, and no doubt the biological sciences will also need to double their expenditure, which is at present more modest but growing fast. This increase in expenditure is well within our capacity as a nation, and essential for our future development.

The Place of Practical Work in School Physics Teaching

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DEFINITION

In this paper the term "practical work" means experiments performed by pupils individually, in pairs, or in small groups. Assembling apparatus, and the making of simple parts, are included, but the emphasis is on *experimentation.*

"Practical work" does not include the making of models (though this may well be done in a laboratory) nor any of the more specialized metal-work or woodwork appropriate to a workshop. Neither does it include demonstrations done by the teacher (assisted or not by the pupils), nor the use of visual aids such as scientific films, nor visits to factories or other places of scientific interest outside the school.

THE PLACE OF PRACTICAL WORK IN ENGLISH SCHOOLS

The importance of individual practical work has been accepted almost without question in English schools during the last few decades. This tradition dates from the early years of the century, when there was a reaction (associated with the name of Professor H. E. Armstrong) against lecture techniques and dogmatic methods then employed: children should discover scientific principles for themselves, and how can they do this except by experimenting? It may be too, that the "practical tradition" is more in consonance with the British temperament; Britons admire Isaac Newton, Clerk Maxwell and Albert Einstein, but they more frequently see themselves in the rôle of Michael Faraday, J. J. Thomson, or Ernest Rutherford.

Recently the Science Masters' Association of Great Britain issued a Policy Statement, *Science and Education.* This Statement refers in the following terms to practical work in the first two years (11+ and 12+ years of age) of the course: "Scientific curiosity should be encouraged and developed by an observational and experimental treatment. Children are eager to do things for themselves and should be guided rather than thwarted; the opportunity should be seized for cultivating the practical skills which will be needed later". Referring to an "Intermediate Phase" for the three years 13+, 14+, 15+, the Statement continues: ". . . the course must be rooted firmly in practical experience of the type which uses experimental work as a means of solving problems rather than for mere verification of previously stated facts, and in which due stress is laid on the importance of correct techniques. Practical work should lead to the formulation of empirical laws and hypothesis and eventually to simple ideas of great and far-reaching generalizations such as the kinetic and atomic theories. In this way science can be shown to be a systematic study. . . ."

The following reference to practical work is taken from the handbook, *The Teaching of Science in Secondary Schools*, produced jointly by the Incorporated Association of Assistant Masters, and the Science Masters' Association: ". . . we believe that the pupil himself should do the utmost amount of practical work which is consistent with his own experimental skill, his safety, and the resources of the laboratory in which he works. Unless a pupil has handled apparatus, has appreciated the unlimited possibilities of error, the necessary repetition and the checking needed to detect errors, he has not gained an insight into modern scientific methods".

Most science teachers try to put these precepts into practice. The time allocation and the equipment for science teaching in English schools are based on the belief that science should be taught mainly through the medium of practical work (details are given in the Appendix).

How far is this belief justified? In the next section we shall consider what use could be made of the extra time available if practical work were abolished or reduced in amount, or, to put it the other way round, what is it that practical work displaces from the curriculum? The later sections are concerned with arguments advanced in favour of an intensive course of practical work, regarded as the backbone of school physics teaching, viz:

Development of skills,
Learning acts and principles,
Inculcation of scientific method,
Maintenance of interest.

WHAT DOES PRACTICAL WORK DISPLACE?

A pupil in an English grammar school who ends his school career by taking a pre-university specialist course in physics will have spent, during his seven years at the school, the following numbers of periods per week on physics.

Year of age	11+	12+	13+	14+	15+	16+	17+
School year	1st	2nd	3rd	4th	5th	6th	7th
Periods per week	$1\frac{1}{2}$	$1\frac{1}{2}$	3	4	4	7	7

The figures in the last line add up to 28. We might say that our physics pupil has spent the equivalent of 28 periods per week on physics for one year. The school's time table might contain 35 periods per week, so that he spends the equivalent of 4/5 of one whole year of his school career on physics alone. Typically he will also have spent the equivalent of 4/5 of a school year on chemistry and at least 1 year on mathematics.

(*a*) Is this too much? If the amount of practical work were reduced, the total time spent on Physics and other science subjects could be reduced, thus liberating hours that could be devoted to subjects such as latin, modern languages, history and geography, civics, or to music, drawing, painting, etc. Thus a better cultural education might be provided. On the other hand, is not physics also a subject of considerable cultural value ?

(*b*) Alternatively we might keep the same numbers of periods to be spent each year on physics, but replace the individual practical work wholly or partly by:

(i) more book learning or lecturing; or
(ii) more demonstration work done by the teacher; or
(iii) greater use of visual aids, such as films; or
(iv) more visits to places of scientific interest outside the school.

English schools often organize a considerable number of such visits, but usually on a voluntary, out-of-school-hours basis, often under the aegis of a school scientific society.

DEVELOPMENT OF SKILLS

Some of our pupils will become research workers in universities, in government departments, or in industry. They should have practice in making experimental enquiries so that they will be able, eventually, to conduct experimental enquiries of their own. It may be objected that school is too early for the acquisition of these skills, which is a matter for the university. Usually, however, the three years of the university course provide much less opportunity for experimental investigation and discovery (as distinct from the routine working through of a list of experiments) than do the seven years of a school course. In any case a skill or an investigational method, once acquired, is not forgotten; it becomes part of the individual's scientific personality. The training value of a postgraduate research course lies, not so much in what is learnt, as in the acquisition of methods of thought, of expression, and of presentation of reports. Much of this could be acquired at undergraduate level, if the universities are able to build on a foundation of practical investigation given in the schools.

Experimental training for future research workers makes sound sense; but how many of our school pupils will ever become research workers? Probably not more than 5%. Another 10% might enter upon scientific careers at a lower level, for which practical skills are necessary. What about the other 85%? They develop some skill in handling apparatus, and some knowledge of its use. This probably will be of some use to them throughout their lives, but the ability to mend fuses, replace tap washers, and do similar jobs could, if it is the job of the school to teach it, be acquired much more quickly in other ways. So far as *useful skills* are concerned, much of the training given to future non-scientists is either useless, or if necessary it could be provided differently with less expenditure of time.

LEARNING OF FACTS AND PRINCIPLES
DEMONSTRATION BY THE TEACHER

Perhaps, however, the main argument for an extensive course of individual practical work lies in the assistance it gives to the process of learning. This is a matter that could be investigated: two similar groups of pupils given the same weekly time allotment for physics, one group spending at least half the time on practical work, the other doing no practical work, but occupying its time in the study of physics in other ways. Which would have learnt more physics by the end of the year? Certainly a pupil remembers something that he sees better than something he is told about or reads about, but need he himself make it happen; would it not be as effective if he sees it demonstrated, or projected on a cinema screen?

Demonstration experiments certainly have their place in any scheme of school physics. Compared with pupils' individual work, demonstration by the teacher has the following advantages.

(i) Time saved by pupils: the teacher does the experiment more quickly and expertly than they can.

(ii) Time saved by teacher. If the teacher has no laboratory assistance, then he spends less time in getting ready one set of apparatus, than in getting ready 15 sets.

(iii) Money saved: obviously one set of apparatus costs less than 15.

(iv) The whole attention of the class can be focused on the demonstrator who can emphasize, even dramatize, the crucial results or readings, and underline the principles.

(v) He can usually get more accurate results than the pupils can.

(vi) Pupils can see how the teacher handles the apparatus (though this would be of no value if they never handle apparatus themselves).

(vii) The teacher can use apparatus that would not be safe in pupils' hands, such as experiments requiring high voltages, or radioactive sources, or inflammable liquids.

If we are concerned solely or mainly with the learning and remembering of facts, then individual work might well be replaced by demonstration, and by the use of films.

SCIENTIFIC METHOD

Learning of facts and principles is one object of physics teaching, but is it the most important object? If so, it is difficult to support the claim that physics is a subject of general educative value, as, for example, latin or history are considered to be. Most physics teachers would admit that facts are important, but that the chief aim should be to persuade pupils to *think* in a simple common-sense, scientific manner, to encourage belief in a rational universe, and to develop a *reasonable* attitude to life. Science, and physics especially, is better fitted than other subjects to develop the ability to distinguish fact from opinion, and to form judgments and base conclusions on the known data. Therefore the science teacher should follow a *scientific method* of finding out the facts and of drawing conclusions; or alternatively, of framing a hypothesis and testing it by experiment. Ideally, it may be claimed, the pupil in his laboratory should learn by solving problems, the stages of this " problem-solving " technique being:

(i) recognition of the existence of a problem to be solved,

(ii) statement of the problem, or of part of it, in an explicit form capable of investigation,
(iii) devising a line of investigation,
(iv) observation and controlled experiment,
(v) collection of data from these experiments,
(vi) the drawing of conclusions, or the formulation of a law,
(vii) the testing of the conclusions in new situations.

Of these seven stages, only (iv) and (vii) need a laboratory; the others can be followed just as well in a classroom. In point of fact, pupils are rarely led along stages (i), (ii) and (iii) at all. More frequently they are " set " experiments to do, often with complete instructions provided; they follow the instructions and get results with which they were already familiar. Nothing is discovered, no reasoning powers are exercised, and no new knowledge is obtained, except the knowledge of how to do that particular experiment.* It is difficult to see how practical work of this kind can do anything to inculcate " scientific method," even if we mean no more by this than simple common sense inductive and deductive thinking. As a training of the reasoning powers, it is a failure. But the failure is not inherent in the method, it is simply that the method is so seldom applied. Why not? Because, as always, it is easier to tell pupils what to do than to persuade them to think out the problems for themselves. And because, if it were applied to all physics, then present syllabuses could not be covered in the time allocated. The answer seems to be:

(*a*) To do less practical work, but what is done should be of a problem-solving or " research " character.

(*b*) To cover more ground by demonstrations by the teacher, who is also acting as the leader of the class upon a path of scientific investigation.

PRACTICAL WORK IS FUN—OR IS IT?

The English science teacher is well used to his younger pupils asking, as they enter the laboratory, " Please sir, what can we do to-day ? "; they are very disappointed if no individual work is in prospect. They do not ask for expensive and complicated apparatus; quite simple things suffice, provided they are allowed to do them themselves.

Perhaps the primary justification for practical work is, in fact the arousing and maintenance of interest. Many pupils derive much pleasure from practical work, and not a few science teachers delight in their own and their pupils' laboratory skills. Devising of laboratory experiments becomes a minor field of research for the teacher, thus maintaining his interest in his subject and the liveliness of his teaching.

Enjoyment of practical work persists, for the majority of pupils, into the later school years. It seems, however, that there is a small minority of mathematically-able pupils who come actively to dislike laboratory periods during their last years. This dislike does not usually become articulate at school, because pupils, seeing no alternative, accept it as natural and inevitable. These pupils slide away from physics and study mathematics at the university level. Consequently it rarely happens, in England, that a *theoretical* physicist has been trained in a physics faculty; he is a mathematician with the outlook of the mathematician rather than the physicist. This is not quite so true of the University of Cambridge, where an intending theoretical physicist would take Part I of the Mathematical Tripos followed by Part II of the Natural Sciences Tripos in physics. But many such students thoroughly *disenjoy* their Part II work because of its practical content. It may well be that this distaste for experimental physics, and the scarcity, in this country, of theoretical physicists with other than a primarily mathematical outlook, is the result of time spent on narrow, unenlightened and over-emphasized laboratory work in the schools. Once again the solution seems to be less emphasis on routine determination of this, that, and the other physical constant, perhaps *less* total time spent in the laboratory, but more emphasis on laboratory observation and experiment as a method of investigation.

CONCLUSIONS

Practical work forms an important part of physics teaching in English schools, possibly half of the total teaching time being devoted to it. In consequence:

(i) Pupils acquire skills essential to the comparatively few future specialists who will become experimental physicists or who will follow careers needing similar talents. For the great majority who will not specialize to this extent in their subsequent careers, the practical skills that may be acquired are probably useful, but not worth the time spent on them, neither does it seem the function of a grammar school to provide them.

(ii) Individual practical work provides a good but very slow method of learning some facts, and of applying some principles. Other methods, especially class demonstrations by the teacher, provide better means of achieving this purpose.

(iii) If the main aim of physics teaching, for future specialists and non-specialists alike, is that of leading pupils to think and reason in a common-sense, scientific manner, then laboratory work should be excellent for the purpose. The author doubts whether much of what is done in English schools achieves this object; it frequently seems to be experimentation for its own sake.

(iv) Even this, however, has considerable value in the early stages (11–15) of a pupil's school career, because he enjoys using his hands, and feels that he has achieved something. It is doubtful whether this sense of achievement persists for *all* pupils in the later stages of school life, and the distaste for practical work then acquired may have something to do with the comparative dearth, in England at the present time, of theoretical physicists with other than a mathematical outlook. However, the fact remains that the majority of physics pupils want to do practical work because they enjoy it.

POSSIBLE IMPROVEMENTS

The author would suggest:

(i) That *facilities* for practical work on the scale aimed at (though not always achieved) in English schools should be regarded as essential. " Facilities " includes laboratories suitable in numbers and size, with the necessary fittings and apparatus; adequate laboratory assistance for teachers; and a sufficient scale of annual laboratory expenditure.

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* " Pupils can spend hours following sheets of instructions without learning much science, just as those who make up radio sets from blueprints often do so without learning much about electricity." (*The Teaching of Science in Secondary Schools, p. 137.*)

(ii) That laboratories should be designed so that they can also be used for class demonstrations (or alternatively, demonstration rooms should be provided as well as laboratories). Some " practical " periods should be spent on demonstration work, and some on individual practical—rather less, perhaps, than in English schools at present.

(iii) That less time should be spent on repetition of the well-known standard experiments that appear in text books, and more on experiments of the " investigation " or " discovery " type linked with the theoretical course. In addition, more " problem-solving " experimental work might be attempted, not necessarily directly connected with the theoretical course. For this, schools do not require large, beautifully finished pieces of apparatus that serve for one experiment only; instead they require a stock of all the bits and pieces of physical apparatus from which problem-experiments can be designed.

APPENDIX: CONDITIONS IN ENGLISH SCHOOLS

TIME ALLOWANCE

Compulsory schooling is from 5 to 15 years of age, and the majority of English children end full-time education at 15. About two children in a hundred stay on to specialize in science, including physics, during the sixth and seventh years (17 and 18 years of age) of a grammar school course. From this 2% the future research workers and other specialists in physics will be drawn, as well as specialists in other fields of science, engineering, medicine, etc. Table I below refers to pupils who may become science specialists. It shows (first column) the years a pupil spends in a " grammar school," the total periods per week spent on Physics (fourth column) and (last column) an estimate of the periods per week spent on practical physics.

A " period " averages 40 or 45 minutes duration. The practical periods are consecutive double or triple periods when the class occupies the laboratory and individual practical work can be done. However, some of the two periods marked as " practical " in the first five years might in fact be spent on class demonstration or (rarely) on theoretical teaching. The three periods assigned to Years 6 and 7 would almost always be used for individual practical work.

Table I

Year of School life	*Year of age*	*General Science or Physics*	*Total time in Physics (periods per week)*	*Physics Practical (periods per week)*
1st, 2nd	11 +, 12 +	General Science	3	2
3rd	13 +	Physics	3	2
4th, 5th	14 +, 15 +	Physics	4	2
6th, 7th	16 +, 17 +	Specialist Physics	7 or 8	3

LABORATORY ACCOMMODATION

Classes in state grammar schools usually contain about 30 pupils. These are sometimes split into smaller groups for laboratory work, but this is unusual except in the fifth and subsequent years. Consequently laboratories are designed for 30 pupils, and the standard area prescribed by the Ministry of Education is a minimum of 960 square feet (99 square metres). The number of *science* laboratories of this size that a school should have is stated by the Ministry to be as follows:

Table II

Size of School	*Type*	*No. of* Science *Laboratories*	*Allocation to* Physics *(suggested by author)*
2—class entry	boys	4	1 or 2
2—class entry	girls	3	1
2—class entry	mixed	4	1 or 2
3—class entry	boys	6	2
3—class entry	girls	4	1 or 2
3—class entry	mixed	5	2
4—class entry	boys	7	2 or 3
4—class entry	girls	5	2
4—class entry	mixed	6	2

The last column shows a possible allocation to the subject physics. It is likely, of course, that laboratories would not all be rigidly divided among the various science subjects; for example, a school having four large laboratories would probably allocate one to physics, one to chemistry, one to biology, and keep one as a general laboratory in which any science subject might be studied.

Some state schools may have a better provision of laboratories than the above table shows. A greater number (55% of a representative sample of 547 schools in 1959) have less than the Ministry suggests. In addition to actual laboratories, store rooms, workshops, dark rooms, preparation rooms, etc., are also provided, on a scale which is very variable from one school to another.

" Pre-university " pupils in state schools usually work in the same large laboratories as are occupied at other times by junior pupils. Sometimes separate " advanced laboratories " are provided: this is a considerable advantage since complicated apparatus can then be left set up for several weeks if necessary.

Independent " Public Schools " are, on the whole, better provided for than are state schools. Typical figures are:

2—class entry	6 labs. (including " advanced " labs.)
3—class entry	10 labs. (including " advanced " labs.)
4—class entry	11 labs. (including " advanced " labs.)

LABORATORY TECHNICIANS AND LABORATORY FINANCE

Numbers of laboratory technicians, and amount of laboratory finance, vary so greatly from one school to another that no general statements are possible. Out of a sample of 694 grammar-type schools (1959) 168 had no laboratory assistance at all. 126 had at least one senior and one junior laboratory steward.

The following figures refer to state grammar schools, and represent the average amounts spent *per year per pupil taking science.*

Boys schools	12s. 3d. per year per pupil.
Girls schools	8s. 8d. per year per pupil.
Mixed schools	10s. 10d. per year per pupil.

Larger sums, over £1 per year per pupil, are spent by independent *boys'* schools, but the figure for independent *girls'* schools is much the same as for state girls' schools.

STATEMENT ON ADVANCED PRACTICAL WORK IN BRITISH SCHOOLS

" The chief consideration in practical work should now be to train the pupil to use the equipment to its best advantage in confirming or rejecting a particular theoretical result, emphasizing how far results do or do not establish the theory. The treatment will depend on whether the object is to establish a principle or to measure a particular constant by the application of a predetermined principle. In the first case it may be necessary to integrate a series of values, each with a different intrinsic accuracy, probably with a graphical illustration, while in the latter case the result would be derived from a few measurements in the region in which maximum accuracy is known to obtain. The result would generally be obtained by computation as distinct from an inferior graphical method. Analysis of the deviations of the experimental result from the expected result and the estimation of systematic errors are of great importance. The pupil should have continually before him the need to exact the maximum possible accuracy from the equipment used: it should thus be a routine procedure for him to check the apparatus before it is used. Thus he should check a stop-watch against a standard clock; zero errors in instruments and end errors in meter bridges and potentiometers should be determined as a matter of course; he should appreciate the necessity for comparing thermometers which are to be used in the same experiment for determining small differences in temperature. Facility should be gained in the estimation of probable errors and in learning to pay particular care in the case of measurements where percentage error is high.

" Opportunies will arise in practical periods when valuable work can be carried out with simple apparatus designed and constructed by the student or with a modification of standard equipment. Success in simple engineering of this type adds to the interest of the work and at the same time provides valuable training.

" It is probably wise to keep as close as possible a correspondence between practical work and attendant theory; in this way undue spoon-feeding is avoided and the illumination of the theory by the experiments is immediate and of greater value. On the other hand there are a number of experiments, such as those on the constants of the bifilar suspension, on mirrors and lenses, cooling graphs, etc., which can be introduced at any stage." (*The Teaching of Science in Secondary Schools, pp. 181–2.*)

Author's Note.—After reading this article a colleague pointed out another reason for making use of practical work, namely *to make phenomena more real through actual experience.* For example, children who never handle magnets cannot have much conception of magnetic phenomena. The phenomena of wave motion gain greatly in reality if pupils have been introduced to reflexion, refraction, diffraction, etc., by means of (*a*) a ripple tank, and (*b*) a generator of centimetric radio waves. We all know the difficulties experienced by a sixth former in obtaining Young's interference fringes when he has never seen such fringes and does not know what he is looking for.

Specialization at School

[A report of a joint meeting of the Manchester and District Branch and the Education Group held on March 4th, 1961]

THERE is widespread concern about the way in which school pupils—and particularly those in the sixth forms of grammar schools—are increasingly being forced to specialize. This is mainly caused by ever-stiffening competition for places in universities, which set high entry standards in order to select the " best " students. Pupils are thus forced to concentrate on the subjects on which they intend to pin their hopes of cornering a university place, and this in turn necessarily means that much of value gets crowded out of their curriculum. There are those who blame the universities for what they regard as a wholly bad situation which prevents the schools from " educating " pupils; on the other hand there are those who support specialization, either reluctantly because they simply regard it as inevitable, or more enthusiastically because they think that specialization in almost any subject is an intellectual discipline valuable for its own sake. Some who hold the latter view nevertheless consider the school sixth forms far too early to start specializing.

This contentious topic was the subject of a lively meeting held at The Manchester Grammar School on March 4th under the combined auspices of the Education Group and the Manchester and District Branch. Many different—and often cancelling—opinions were ventilated by a large gathering of people, many of whom were themselves considerable specialists in the art of teaching. As one might have expected, no general solution was forthcoming. It was clear, however, first that specialization at school was considered by the majority to be inevitable, and secondly that the amount of it which a pupil could stand without permanent damage depended on his ability; the first-rate pupil could specialize and still find time for a range of other activities both academic and otherwise, whereas the lesser light became ploughed into a groove from which he could not see out. They might both get into universities, but the end products were very different. The main question was: given pupils of mixed ability, how early in the school should any specialization be introduced?

The discussion was opened by two speakers—Lord James of Rusholme, the High Master of the Manchester Grammar School, and Mr. A. D. C. Peterson, the Director of the Education Department at the University of Oxford.

Lord James considered that there was a misapprehension in the air concerning the alleged increase of specialization at school. Actually there was more intense specialization in the 19th century—but in different subjects, for example the classics. This was not now even regarded as specialization, but got away with it under the heading of " culture ". Lord James considered his own education 35 years ago to have been much less general than that available at M.G.S. to-day.

He also denied that there were different types of mind suited to different specialities; the qualities of mind that inspired a scientist to want to find out about the universe were basically the same as those which urged a musician to unravel the complexities of a fugue. There were not different *types* of mind, just good ones and lesser ones. There was a temptation to assume that a boy who was found not to have read anything needed some remedial treatment (for example, in the form of A-level French) and that this would convert him to a broad-minded fluency. It would not ; a works chemist who did not read Proust in bed omitted to do so simply because he was not that sort of chap.

If the tendency to mistake differences in " line " for differences in ability were resisted, it at least prevented one from setting one's sights too high: one did not then assume that a boy whose ability in one subject was mediocre must be good at something else, and was probably in the wrong " line ".

One factor which dominated any discussion of school curricula was that the social background of pupils receiving a higher education had changed enormously over the last 30-50 years. Many of those attending grammar schools and universities to-day came from homes where there was no atmosphere of good conversation and good music, and where glossy magazines took the place of books. Under these circumstances it was very surprising that specialization was not more severe than it is, in view of the immense difficulties to be overcome before a general education could be given to this new social group, whose background gave no help.

Another factor which made it surprising that there was not more specialization was the sheer expansion of knowledge, which meant that one must go much further in any subject in order to reach the frontier. Indeed, it was doubtful how long 3-year university courses could be retained. Lord James read Chemistry at Oxford in 1930, and now found that two-thirds of the questions in finals to-day were on work not even known about then. The only hope of being able to give a more general education —on, for example, the German model—was to increase the university courses to five years and thereby to make it unnecessary for the student to start his specialist education at school. This would only be possible if the Treasury would produce the money. Many countries had longer university courses than ours but this was not in itself sufficient—it was worth asking whether in fact young Germans or Frenchmen showed greater political awareness than did the products of our educational system, or whether young Americans were more cultured.

Our attitude could be summed up as conservative, but not complacent, and we had to think about what we really wanted. It is all very well to say that we want to produce a generally educated man—but we must then decide what we mean by this. Certainly one expects an " educated " man to have some acquaintance with the facts of a range of subjects at a superficial level; everyone is expected to know who wrote *Hamlet*, for instance. What is much more important is that he has living interests, which lead him to self-education. The aim of school education should be to stimulate interest and to spark off the life-long process of self-education—i.e. to

" open windows ". This could be achieved only by avoiding premature specialization and by exposing pupils to as wide a range of subjects as possible for as long as possible. School timetables must be so arranged that an early choice between Arts and Science is not required, and there must be easier provision for rectifying a wrong choice—even at the expense of incurring a delay of a year or so.

Schools must resist pressure from the universities, and insist on cutting down the A-level syllabuses; the snag was that, in practice, committees set up to do this always resulted in increasing the syllabus, because each committee member thought that at least *his* pet subject ought to be included.

It was also necessary to resist the temptation to use the teaching of non-specialist subjects as a way of filling the timetables of the more feeble teachers, while the better teachers got on with their specialization. " Minority time " must be taken seriously, and be adequate in quality as well as quantity. Arts subjects for scientists, and vice versa, must be taught by the best teachers if interest were to be stimulated. Paradoxically, the severely specialist teaching of the 19th century was often an excellent general education in the hands of a gifted teacher, his personal qualities and general attitude supplying a breadth outside his subject.

There were two schools of thought about the use of minority time; one, represented by Mr. Peterson, thought that it should be concentrated on an unrelated A-level subject; Lord James thought that one should concentrate on the element of stimulation. If non-specialist teaching would not be taken seriously unless examined, then the general paper was the answer, and the Headmasters' Conference had supported the recognition of general papers for university admission since 1948. It was all too well known that if an unrelated A-level subject were required, schools could get their pupils over this hurdle without necessarily inspiring them. An arts specialist could be made to do, say, A-level physics (and M.G.S. would get him through!) but it would not add much " culture " unless his heart leapt at the thought of the neutral point in a magnetic field. Ideally, the non-specialist teaching should be like a good W.E.A. course, and victory is achieved if the pupils go off and buy Pelicans for themselves.

Finally, all the mental cross-fertilization and Halls of Residence provided by universities would come to nothing unless the universities succeeded in continuing the process started by the best schools.

Mr. Peterson, the second of the opening speakers, commented on the strikingly wide measure of agreement between himself and Lord James; they differed only on minor, but important, points. He agreed with the misgivings about early specialization at school. In grammar schools this often started at about 14, and sometimes even earlier. He had recently met two boys who were doing history at a public school, and found that neither had ever been in a science laboratory nor had a science lesson. Sixth-form education was best achieved by specializing in a limited number of subjects (he had chosen Latin and Greek), but it was bad to specialize too early or too completely. Two investigations (one sponsored by the Oxford Department of Education and the other by the British Association) had found that 80-90% of sixth-form time was spent on specialist subjects. The recommendations of the Crowther Report had been widely agreed with, but why had so little been done to carry them out ?

Lord James had asked for evidence that the allegedly broader education in the United States, or on the Continent, produced more cultured citizens. It was hard to get evidence either way, but odd facts emerged—for example, the Hamburg authorities spend more public money on the Arts per year than the whole of Great Britain.

Most people agreed that specialization, at least in the sixth forms, was necessary—and many considered it a good thing for its own sake. There was a danger in acquiring superficial facts, and unless a subject was studied in depth the pupil never got to the stage where he could sharpen his mind by arguing with his teachers and weighing the evidence on disputed points.

One of the main arguments against early specialization was the danger of making the choice on inadequate grounds. Pupils often did not know what they wanted, and even waited for the O-level marks to see what they were good at ! Marginal differences of ability at that level were poor grounds for the choice. A good performance in O-level Latin might in fact be as good an indication of latent ability in Physics as in Classics. O-level Chemistry was considered by some as a mere test of memory, akin to learning the London telephone directory, and might have little to do with scientific ability. Lifelong interests—and abilities—were simply not stabilized at O-level and the choice should be postponed as long as possible. Even then, as Lord James had said, easy transition should be a feature of the system.

Possible solutions to the problem of over-specialization were either to give more " minority time " (the British Association wants 12 periods a week plus homework)—or to insist on a wider spread of main subjects. It was in any case silly to call a 17-year-old a historian or a scientist and such labels would be less likely to be used if arts and science main subjects were mixed. As Lord James had said, the qualities of mind required were the same. If, say, four mixed A-level subjects were taken, it would be necessary for universities to accept a lower standard; this would save the time at present spent by 25-30% of candidates who took A-level twice in the hope of attaining the standards required for university entrance. In Mr. Peterson's view ,this could be done without requiring university courses to be longer than at present, and would enable the final choice of subject to be delayed until arrival at the university itself. This scheme would make the sixth-form timetable easier to organize than would a mixture of specialist and general subjects.

A lively, and at times provocative, discussion followed; most of the participants were schoolteachers, but there was a leavening of university and technical college teachers, and one or two industrialists. One of the latter questioned the need to have a broad education at all, which Lord James defended on two grounds; first, that a broadly educated person got more out of life because he had more interests, and secondly that it was the duty of schools to provide citizens with something to contribute to running the community. Mr. Peterson regarded a general education as necessary equipment to cope with a rapidly changing world. Most of the speakers agreed that specialization was nevertheless necessary; the questions at issue were: at what stage should it begin, and how could a compromise be achieved which produced generally educated people with specialist knowledge ?

Lord James considered that any education was specialist from the start and it was merely a question of amount and subject, but that specialist studies could themselves be the means of a general education. At the other extreme, some felt that specialization should be left to the universities. Others felt that only the atmosphere of the universities could really give a *general* education. Many thought that specialization from the year before O-level, as was often the case, was far too early. Clearly there was no single answer; the optimum time depended on the ability of the pupils. The more intelligent pupils could safely specialize late, whereas the duller ones would need to start in the middle school if they were to reach a satisfactory standard by the time they left. If specialization were to be offset by adding general studies subjects, the ability of the teachers was crucial. It was pointed out that the present teachers were usually specialists themselves, and often had neither the interest nor the ability to teach outside their specialist subject; good teachers could interest pupils in anything, but there were too few of them to base a system of general studies on. The ideal was to have a teacher, who was known to and respected by his pupils as a specialist and for his personal qualities, teaching as a sideline a general-studies subject in which he had a genuine interest. The pupils would tend to carry over their respect for him to the new subject. One speaker ascribed his present interest in music to the influence of his physics master in this way.

It was alleged that the average sixth form pupil welcomes specialization and is reluctant to make use of any opportunities not to specialize, and also that the discipline of specialization was necessary to make pupils work. Indeed, the view seemed widespread that if general-studies subjects were to occupy the time-table, there should be examinations in sight to encourage application, and the new A-level general studies papers were welcomed.

Some interesting experiments were described in which attempts were made to combine specialist and general subjects. One school tried this in the lower school with an experimental group of 25 boys and a wide individual choice of general subjects. The organization was a formidable task, and the result was 19 separate time-tables. The same school, at sixth form level, prescribed 3 A-level subjects, and a choice of 3 out of 12 general subjects. Other schools did not go as far as this, but introduced borderline subjects, such as history of science for scientists, and mathematics for arts pupils. The choice of subjects was indeed difficult; it was suggested that it was far better, for example, for scientists to learn something about French culture than to do O or A-level French language. However, Lord James pointed out that boys at school usually simply had not the ability or the maturity to study a subject like French culture, whereas they could be taught the mechanics of the language. The cultural aspect was best left until university level—indeed, Brighton University College was proposing to hold a course on European studies. Another point was that grammar schools, whose staff : pupil ratio was only about one-third that of the universities, could not afford small groups, and had to economize in the amount of choice allowed.

Several speakers had misgivings as to the way in which pupils chose their specialist subjects; one doubted whether parents were given enough say, while other thought that parents either were willing to leave it to the expert advice of the schoolteachers, or that they should do so whether willing or not, on the grounds that parents' choices were often either biased (by family tradition), or utilitarian (e.g. " science pays "). Another thought that the pupils themselves did not have enough say, which brought the reply that boys at or before O-level usually did not know what they wanted, or, if they did, they were not as well able to choose wisely as their teachers were. Indeed, there seemed to be the paradox that only those with sufficiently inspiring teachers were likely to be able to make their own choice wisely, while the rest had to leave it to their teachers !

In conclusion, Mr. Peterson pleaded that the design of school buildings should not act against adequate mixing of those specializing in Arts and Science; often one found the Arts and Science sixth form classrooms in separate parts of the building—and even sometimes separate staff common rooms.

Lord James emphasized, in answer to a question, that there was indeed no reason why physics should not form the basis of a truly general education; the difficulty was to find teachers able to teach it that way. In the end, culture could not be taught, only absorbed. It was better to inspire a scientist to read some English literature than to give him an A-level course in it, and to let him listen to some music than to push him through examinations in it. The object of any teaching should be to inspire a continuing interest, but, in any case, two-thirds of those one tried to apply any cultural scheme to would defy you to interest them in anything. Schools must do all they can to provide a substitute for a cultured home background, where this was missing.

Thus ended the discussion: no very clear conclusions were reached; indeed there obviously could be no simple answer when such a wide spectrum of interests and abilities is involved. It is indeed remarkable that our higher education system, as a compromise, works so well.

J. E. Geake.

Notes and News

First Annual General Meeting

Notice is hereby given that the first Annual General Meeting of The Institute of Physics and The Physical Society will be held at 5 p.m. on Tuesday, July 4, 1961, at the Institute and Society's headquarters. Attendance is limited to Fellows, Associates and Graduates of The Institute of Physics and to other Fellows of The Physical Society. The business to be conducted is the consideration of the Council's report and the accounts and balance sheets for 1960, the declaration of the election of the honorary officers and other members of the Council nominated, and the election of auditors. A copy of the annual report and accounts is printed in this issue of the *Bulletin*. Further copies will be sent on request.

C. G. WYNNE,
May 15, 1961. *Honorary Secretary.*

Rutherford Jubilee International Conference

The Rutherford Jubilee International Conference which is to be held at the University of Manchester from September 4-8, 1961, was announced in the January *Bulletin*. Members should note that all who wish to attend must apply by June 21. It is expected that the number of applications will exceed the available accommodation. Further information can be obtained from Dr. J. L. B. Goldfarb, Rutherford Jubilee International Conference, Physics Department, The University, Manchester, England.

Russian for Scientists

An intensive residential course of Russian for scientists is being held in the University of Birmingham from September 11-23, 1961. Details and application forms may be obtained from The Secretary, Russian for Scientists Course, University of Birmingham, Edgbaston, Birmingham, 15. Closing date for applications is May 31.

Antarctic Research

The International Council of Scientific Unions Special Committee on Antarctic Research (SCAR) now maintains a register of scientists wishing to work on Antarctic expeditions of other nations. SCAR is merely acting as a centre which may put suitable scientists from other countries in touch with National Committees who could use their services to advantage. Further arrangements for the employment of individuals are then a matter of negotiation between the expedition organization and the person concerned. Men with previous polar experience would be most suitable. Registration forms are available from The Assistant Secretary, The Royal Society, Burlington House, London, W.1.

Conference on Magnetism and Magnetic Materials

The Seventh Annual Conference on Magnetism and Magnetic Materials will be held in Phoenix, Arizona, November 13-16, at the Hotel Westward Ho. This conference is sponsored jointly by The American Institute of Electrical Engineers and the American Institute of Physics, in co-operation with the Office of Naval Research, the Institute of Radio Engineers, and the Metallurgical Society of the A.I.M.E. Further details can be obtained from the local chairman, Peter B. Myers, Motorola Semiconductor Products Division, 5005 E, McDowell Road, Phoenix, Arizona, U.S.A.

Medicine's Challenge to Engineering

The 1961 Jephcott Lecture will be given by Dr. D. G. Melrose on " Medicine's Challenge to Engineering ", at the Royal Society of Medicine, 1 Wimpole Street, London, W.1, on Thursday, May 18, 1961, at 7 p.m. Admission is by ticket only, obtainable from the Secretary, The Jephcott Lecture Trust, 1 Carlos Place, W.1.

Addresses wanted

The Institute and Society no longer has effective addresses for the members named below. Any members who can supply current addresses are asked to notify the Secretary.

Name	*Last known location*
ASSOCIATES	
J. E. Brickell	Farnborough, Hants.
I. A. Gatenby	Portland, Dorset
N. B. Rajchenbaum	Bayswater, London
GRADUATES	
J. A. Gildea	Thorne, Yorkshire
J. F. P. James	Hunters Hill, New South Wales, Australia
G. J. Partington	Swansea, Glamorgan
J. S. Turner	Trinity College, Cambridge
J. L. Williams	Rugby, Warwickshire

Letters to the Editor

The Endless Frontier

I should like to make two comments on the text of Professor Armytage's lecture as reproduced in the March 1961 issue of the *Bulletin*.

In the penultimate paragraph of the section headed " Electronic Computers " it is implied that automation was mainly responsible for the downward trend in the capital cost per kW of the C.E.G.B.'s nuclear reactors. In fact the degree of automatic control is roughly the same in all these reactors. The decrease in cost per kW of Hinkley Point over the earlier reactors is mainly due to an increase in volume of fuel per unit volume of the core.

Again, an error occurs in the fourth paragraph of the same section. It is stated there that D. R. Hartree built the first machine at the N.P.L., Teddington, known as A.C.E. In fact Professor Hartree had nothing to do with the building of A.C.E., which was under the direction of Womersley, Turing and Colebrook. Professor Armytage is probably thinking of the EDSAC 1 at Cambridge which was completed in 1949 under the direction of M. V. Wilkes, with which Hartree also was intimately concerned.

L. Rotherham (*F.Inst.P.*).

C.E.G.B.,
Bankside House,
Summer Street,
London, S.E.1.

The Teaching of Relativity

The proposal by Dr. Pearson to teach the mass-energy relationship on the basis of the properties of de Broglie waves seems to me to be most unsuitable. Although the de Broglie wavelength of a particle has a physical meaning and can be measured by diffraction experiments, this is not the case for the frequency. Since the zero of potential energy is arbitrary only differences of "frequency" have any meaning. The de Broglie frequency and phase velocity cannot be measured and have no physical significance, unlike the corresponding quantities for electromagnetic waves. Students must be warned not to treat too literally the analogy between the wave-particle relationships in the different cases.

It is undesirable that such an abstruse and non-physical basis should be used to introduce the mass-energy formulae, especially when teaching non-physicists. A much more satisfactory approach is to present $m=m_0/\sqrt{(1-v^2/c^2)}$ as an experimental result. The laws of conservation of mass, energy and momentum are taken as postulates. Then consideration of the head-on collision of two identical particles easily shows that potential energy must have mass given by $E=mc^2$. It is then simple to generalize the result.

J. W. Warren.

Brunel College of Technology.

Appeal for the Physics Trust Fund

The following donations or subscriptions were received between March 23 and April 24, 1961:

(*a*) From Members

Mr. K. J. Anderson
Miss J. W. Auton
Mr. A. G. Bastin
Mr. G. H. Cockett
Mr. R. O. W. Fletcher
Mr. A. Gelbtuch
Mr. K. F. Hale
Mr. Khadim A. Hashmi
Mr. A. P. Holwell
Mr. D. G. Jaquess
Mr. G. J. Lloyd
Mr. C. W. Oatley
Dr. D. Parsons
Mr. B. O. Payne
Professor G. D. Rochester
Dr. D. F. Shaw
Mr. J. R. Smith
Mr. G. A. Sutherland
Mr. R. J. Taylor
Dr. L. Thomas
Mr. R. P. Thorne
Dr. D. T. Turnbull
Mr. L. Wilcox

(*b*) From firms

Evershed & Vignoles Ltd.
Macmillan & Co. Ltd.
Pyrotenax Ltd.
Welwyn Electric Ltd.

The total received or promised by April 24, 1961 (including those previously announced) was:

	£
Gross value of industrial firms' covenants over seven years (including tax recoverable)	99,480
Single donations from firms	7,460
Total from Industry ...	106,940
Gross value of 227 members' covenants over seven years (including tax recoverable)	4,937
Single donations (297) from members...	766
Total from members ...	5,703
Grand Total at April 24, 1961 ...	£112,643

Forthcoming Institute and Society Meetings

Date	*Place*	*Speaker*	*Title and other details*	*Time*	*Branch or Group*
May 17	**London** Headquarters	Mr. M. Zvegintzov (*National Research Development Corporation*)	Discussion meeting on **The future of deep low temperature engineering**	4.00 p.m.	Low Temperature
May 17	**Newcastle upon Tyne**	Professor Z. Kopal (*University of Manchester*)	**The physics of the moon**	5.30 p.m.	North-Eastern
May 18	**Malvern** Royal Research Establishment	Mr. C. R. Ditchfield, A.Inst.P. (*Royal Radar Establishment, Malvern*)	Visit to Royal Radar Research Establishment, followed by a talk on **The physics and uses of masers** Registration is necessary	2.00 p.m.	Midland
June 1	**London** Imperial College	Mr. K. Hacking (*B.B.C. Research Laboratories*)	**Secondary flare in lenses**	2.30 p.m.	Optical
June 8	**London** Imperial College		Symposium on **Medical acoustics**		Acoustics
June 9	**Oxford** Clarendon Laboratory		**Summer visit to the Low Temperature Department of the Clarendon Laboratory** Registration is necessary	11.00 a.m.	Low Temperature
June 16	**Manchester** Literary and Philosophical Society		All day meeting on **Spectroscopic studies using time resolution techniques** Registration is necessary	10.30 a.m.	Applied Spectroscopy
June 17	**Scarborough** High School for Boys	Mr. N. Clarke, F.Inst.P. (*The Institute of Physics and The Physical Society*)	Summer Meeting and Lecture **Winds of change in physics education**	11.00 a.m.	Yorkshire
June 24	**London**		**Summer meeting and visit to Royal Naval College, Greenwich** Registration is necessary	11.00 a.m.	London and Home Counties
June 30	**Winfrith** Atomic Energy Establishment		Summer Meeting — Visit to Atomic Energy Establishment Registration is necessary		South Western
July 10 to 12	**Durham** The University		Symposium on **Thermoelectricity** Registration is necessary. Programs and application forms may be obtained from Professor D. A. Wright, F.Inst.P., Department of Applied Physics, Science Laboratories, South Road, Durham.		
July 10 to 14	**London** Imperial College		Conference on **Optical instruments and techniques** (arranged under the auspices of the International Commission for Optics by The British National Committee for Optics)		Optical
July 11	**London** Imperial College	Dr. H. H. Hopkins, F.Inst.P. (*Imperial College*)	**Thomas Young Oration** **Applications of frequency response techniques in optics**	6.00 p.m.	

Reviews of Books

SCIENCE AND GOVERNMENT

By C. P. Snow

London: Oxford University Press. Pp. vi + 88. Price 9s. 6d.

This little book is the substance of three lectures delivered at Harvard last year. About two-thirds of it are given to an account of the quarrel between Sir Henry Tizard and Lord Cherwell, who for much of the period was still Professor F. A. Lindemann of the Clarendon. Since it has appeared, and indeed even before, the book has received a great deal of notice, much of it critical, including a *Times* "turnover" on three successive days written by Professor R. V. Jones, who from his war time experience in Scientific Intelligence and being a former pupil of Lindemann's, is in a good position to know. Sir Robert Watson Watt has also written in the *Saturday Review* (March 4) to refute some statements in it.

Broadly speaking, Sir Charles' thesis is that Cherwell was an *eminence grise* whose ideas on the scientific conduct of the war were vitiated by a love of gadgets and who managed to deprive Tizard of much of the influence for good he otherwise might have had. In fact, it is less a thesis than the plot of a short story, and a very good story Sir Charles makes of it as might be expected of a famous novelist. What is most surprising is that he missed the chance of a better plot which would have had the advantage of being true.

Instead of a straight-forward "western" hero and villain, what actually happened was curiously like a Greek tragedy, the tale of two men each of quite outstanding ability in rather similar ways, but of very different temperaments, each devoted to the task of preparing for and winning the war, hurting and hindering each other because of some poison which had come into an ancient friendship.

I knew Lindemann well in World War I, living in the same house for nearly two years; for nine happy years I served under Tizard at Imperial College; I worked under both in World War II, and am proud to believe that I retained the friendship of both throughout the war years and after. Tizard was a man of very many friends and of few enemies. Lindemann had many enemies and possibly rather enjoyed them, but those who had most to do with him and saw him closest were of quite another opinion, as I found in writing his obituary for the Royal Society. The judgement of those who knew him best is to be preferred.

Tizard was the greatest genius at applying science to tactics this country has ever known. This was very largely because of his ability to see things from the soldier's point of view as well as from the scientist's. He never backed things which could not be made operational and was able to get those he did back accepted, if not with enthusiasm at least with a reasonably open mind. Lindemann's great contribution to the war was rather in applying scientific, and especially numerical habits of mind to economic and administrative problems arising during the war and advising Churchill accordingly. I think that Sir Charles is wrong in accusing him of "gadgetry". After all, most applications of science to tactics depend on some sort of "ironmongery", first it has to be invented and then the best way of using it devised. Certain naval operational problems are probably the most important exception. Never was there such a profusion of gadgetry as in radar, which Sir Charles rightly regards as the most important scientific war winner, and which he accuses Lindemann of trying to put second to infra-red detection. It is true that Lindemann supported many of the radar "gadgets"—A.1, gee, oboe and H2S, the last most enthusiastically and perhaps for the wrong purpose.

The bombing of German cities in 1942-44 had Lindemann's support which Sir Charles thinks mistaken. He omits to mention that Lindemann had earlier accepted great unpopularity with the Air Force by proving that few of the bombs in the earlier night raids had got anywhere near the target. Undoubtedly Lindemann was wrong in some of the calculations he made as to the output of bombers needed. But the failure of area bombing was not due to this. In fact 70% of the dwelling units in the major German cities were destroyed (*U.S. Strategic Bombing Survey*, quoted by Blackett, *Military and Political Consequences of Atomic Energy*, p. 196), but little decrease in production occurred till well on in 1944, when it became possible to make precision attacks on factories. The Germans were tougher than we expected, not enough allowance was made for the excess accommodation in a rich western society over the essential minimum, and, what would have seemed incredible when the decision to bomb was taken, the German economy was not fully geared to war, there was still plenty of slack. Perhaps we should have realized these things and abstained, but it was the only way of helping Russia, which it did by tying up a great deal of German effort in anti-aircraft, in radar and in night fighters.

In the last part of the book Sir Charles discusses the part that science and men of science could and ought to play in government. Here his wide administrative experience makes his opinion of great value. He is concerned that we are losing a sense of the future and drifting happily along. He thinks that science can supply the missing foresight. Like most of us he is concerned at the small number of administrators in the country who have had any scientific education. He has weighty things to say about Advisory Committees, and how objectives should be chosen, praising that of the original Tizard Committee on Air Defence. I have always understood that Tizard himself was responsible for the latter, having rejected an earlier suggestion that he should be asked simply to consider improvements in anti-aircraft artillery. This was the Committee that started radar and it shows Tizard's foresight that in the end radar reformed A.A. Science should deal with problems and not be tied to particular methods.

G. P. THOMSON.

INTRODUCTION TO ATOMIC AND NUCLEAR PHYSICS

By Otto Oldenberg

London: McGraw-Hill Publishing Company Ltd. Pp. xiii+ 380. Price 62s.

The presentation of the vast array of fact and theory sometimes called " Modern Physics " offers as much of a challenge to the author as does its assimilation to the student. The outstanding problems for both are the high factual content of the subject, the complex pattern of its historical development and the conceptual difficulty of the necessary theory. The extent to which these aspects of the subject receive prominence depends on the class of student for which a particular book is written. In the present instance Dr. Oldenberg, who bases his book on lectures given at Harvard University, has in mind " readers who have taken a one-year introductory physics course and are familiar with the elements of chemistry ". In terms of the British educational system this means approximately G.C.E. A-level qualification in physics, or chemistry, or both, although not necessarily in mathematics, and the book could form a useful text for either first or second year University courses. The balance struck between the historical and the factual approach is excellent, and for the ordinary or general degree student in science, or for the mathematician wishing to acquire a physical background, the treatment is ample. The biologist or arts student, however, will probably not get very far, while the Honours student in physics or chemistry will need at many points some additional theory. The author points out that the examples, with which each chapter is liberally furnished, provide the mathematical content which is absent from the text, and the hints and answers ensure success in solution. This device makes the book suitable for a wider range of readers than it might be if the theoretical treatment were more explicit, but intensive problem-work, admirable as it is, is on the whole not a prominent feature of university courses in modern physics in this country. Nor is it necessary that the calculus should be treated with a deference which confines it to small print and to examples.

The structure of the book is logical. It is divided into seven parts of considerably different length, which lead the reader in easy stages from Avogadro's hypothesis to the origin of cosmic rays. The treatment is everywhere clear and informative and great care has been devoted to explanation and illumination of difficult concepts or discoveries. When a subject is deemed to be outside the scope of the treatment this is admitted ; unsupported statements, which leave a student puzzled, are rarely offered. The preambles which accompany each Part and Chapter, to define the scope of the following sections, are most helpful and might well be adopted by many other authors. Part I (Structure of Matter) and Part II (Electronic Structure of Electricity) are strictly elementary and require little previous knowledge. Part III (Quantum Structure of Light) and Part IV (Electronic Structure of Atoms) cover the progress of atomic physics in roughly the period 1900-1925; strict historical order is here discarded in order to have the idea of the nuclear atom immediately available. The Bohr theory of the atom is perhaps somewhat over-emphasized in view of its later amplification by wave mechanics, but an excellent treatment is given of the idea of wave-particle duality. Applications of atomic theory to photochemistry and to the ionosphere, often overlooked in atomic physics texts, are mentioned. By the end of Chapter 11 (X-rays) the book is proceeding at a level clearly appropriate to the second year of a university course.

Part V is a brief single chapter on Wave Mechanics. Although very well written, it suffers from the exclusion of formulae, especially that of the wave equation. Part VI is another single chapter on the modern theory of solids; it skilfully compresses many essential ideas into 10 pages. Part VII (Nuclear Structure) occupies about one third of the total page space of the book and has chapters on Isotopes, Radioactivity, Transmutation, Fission and Fusion, and Cosmic Rays. It is in this branch of modern physics that the problem of excessive detail becomes most acute and it is doubtful whether Dr. Oldenberg has solved it. Had this part of the subject been treated at the general level of the earlier chapters of this book it would have occupied far more space; in order to contain it within 130 pages many aspects of interpretation have received scanty treatment. Even the compound nucleus hypothesis comes in apparently only " for the sake of computation " and not as a result of the important experiments on neutron resonance levels. Despite this the nuclear chapters are well arranged and extremely readable. The historical matter (in small print) is well chosen.

The text of this book is not encumbered by detailed literature references, but a useful bibliography is included as an Appendix. The author uses the MKS system of units throughout, and although a nucleus of size $0{\cdot}6 \times 10^{-14}$ metres may present a somewhat awkward appearance to the older reader, no real difficulty arises. There are a few minor typographical errors, but on the whole the book is well produced, although the reviewer's copy is marred by poor reproduction of most of the photographs. It may be recommended for use in university courses and many professional physicists would find it both helpful and stimulating.

W. E. Burcham.

INTERNATIONAL EDUCATION IN PHYSICS

(Proceedings of the International Conference on Physics Education 1960)

Edited by Sanborn C. Brown and Norman Clarke

Cambridge, Massachusetts: The Technology Press. London: John Wiley & Sons, Ltd. Pp. xvi+191. Price 36s.

During the last few years a marked growth in physics education in schools, technical colleges and universities has taken place in this country and in many others Governments are also slowly realizing the urgent importance of increasing both the numbers and quality of the physicists and technologists trained each year. It is not surprising therefore, that the methods of teaching physics have been recently under critical examination in several countries particularly in the United States. That this work should lead to an International Conference is, perhaps, inevitable. It must be noted, however, that Professor Sanborn Brown and his colleagues in the United States realized this very quickly and are to be congratulated for persuading various bodies, notably the International Union of Pure and Applied Physics, to sponsor a truly International Meeting to discuss current problems encountered when teaching physics at all levels.

The Conference was held in Paris during the first week of August, 1960, and was attended by 86 physicists from 32 countries. Inevitably, at the first meeting discussions covered a very wide field. For example, the role of physics in general education, examinations, selection of students, laboratory work, training of teachers, postgraduate training, the use of films and television, the teaching of mathematics to physics students, and several other topics were all included. Thus the discussions ranged widely from the need to diseminate a general knowledge of physics among school children in secondary schools of several grades up to present trends in Ph.D. training. It is to be hoped that further conferences will be held soon which will deal at greater length with selected parts of this wide field. The purpose of this first conference was clearly exploratory. The very lucid report edited by Professor Brown and Mr. Clarke demonstrates clearly that it was most successful. The report consists of twelve chapters, each of which is devoted to one of the main addresses. Each chapter contains a brief summary of additional contributions and the subsequent discussion. Where appropriate, extracts from papers submitted to the conference beforehand are also included. The editors have contrived to make these parts of this report of the greatest interest, much semi-irrelevant material must have been omitted and the result of a careful selection of the material is highly successful. The full conference programme is given after the twelve chapters, together with a list of the distributed papers, and of the books on exhibition during the conference.

Professor Zacharias, of M.I.T., gave a most illuminating account of the Physical Science Study Committee which has developed a radically new physics course for secondary schools in the United States. Further details of this course are now available in this country and it is clear that, in part at least, it warrants careful trial in some of our secondary schools.

Inevitably, the conference discussed the impact of television and films in the teaching of physics. Professor Harvey White, of Berkeley, gave the conference the benefit of his unique experience of using the medium of television for teaching physics to secondary school students. His enthusiasm for the new technique is unbounded, and the evidence he presented is so convincing that a serious experiment, involving many hours of transmission time, should be made soon in this country.

Good evidence was also presented to the conference that films can be of great value for undergraduate classes. This medium is hardly used at all in this country so, again, it is clear that experiments must be made urgently. Details of films shown to the conference are included in the report, also information on many others. It seems likely that even university students may benefit from seeing some of the many films prepared under the auspices of P.S.S.C. Copies of many of these films will be required for extensive experiments and, therefore, considerable funds will be needed. The methods used in the teaching of honours physics students have become completely stereotyped in this country. Very few lecture demonstrations are performed, even in first-year classes. The use of films could be a worthwhile development, but it is probable that some special films of the right level will be needed. Thus, if the first trials using existing films are encouraging it is likely that a considerable national expenditure may be necessary to produce good films for undergraduates in this country. It is to be hoped serious thought will be given to this problem by the Royal Society, and The Institute of Physics and The Physical Society, and that gifted teachers will be willing to give their time to the making of films.

The conference report is excellently produced and most skilfully edited. All physicists engaged in teaching, and those who are concerned with recruiting staff for Government laboratories, and industry, should read this book.

It is to be hoped that I.U.P.A.P. will be able to hold further conferences on an international level so that experiences under very mixed conditions may be shared. The General Assembly of the Union, held in Ottawa last September, set up a Commission of Physics Education and avowed its intention of supporting international collaborations in the study of educational methods. Thus there is a good reason to expect further developments in the future.

C. C. BUTLER.

THE ETHICAL DILEMMA OF SCIENCE AND OTHER WRITINGS

By A. V. Hill

London : Oxford University Press. Pp. xiii + 395. Price 52s.

Few books could be more timely than this one. It consists of a number of speeches, addresses, essays, appreciations and so on, culled from over a wide region of the distinguished author's activities. Mathematician, biologist, traveller (even missionary), University M.P., administrator, he has experienced many of the sciences at first hand, and not a few aspects of them have become alive at his touch. This is perhaps the essential point. Rather too many people have written about the various "dilemmas" inherent in the scientific outlook. Most of such folk have tended to be spectators rather than "poets". (Classically, we recollect that a *poet* is a person who makes something, and that is just what Professor Hill is, and has been, all his life : even if he occasionally breaks out into verse as well).

His particular dilemma is centred around the problem of the essential spirituality of science accompanied always by the risk—and sometimes more than the risk—of its degradation for material ends in a jarring world, the outlook of which is often far from noble. Moreover, sacrifice there must be, and disagreement with those whose friendship one values, and whose opinions one respects. All this is closely bound up with an ever-growing tendency for people to become absorbed in technique, however necessary, rather than in breathing the fresher air of deep philosophical issues. That Professor Hill knows all this so well should be an encouragement to the overburdened. He deals with serious matters with a lightness of phrase which helps to break down barriers, and so inspire confidence. Much of his life has been devoted to this task, not least in helping youngsters, of which the present reviewer was privileged to be one, some thirty-five years ago.

Included in this collection are several " memories " of outstanding scientists—e.g. Bertram Hopkinson, Einthoven (of the string galvanometer), R. H. Fowler and William Hartree. We are grateful to have these, both for what they say and for what they teach.

Every page is interesting, partly grave and partly gay. And as the author himself puts it—" Anyhow that is what happened ".

F. I. G. Rawlins.

MODERN UNIVERSITY PHYSICS

By J. A. Richards, F. W. Sears, M. Russell Wehr and M. W. Zemansky.

Massachusetts and London: Addison-Wesley Publishing Co. Inc. Pp. xvi + 993. Price 60s.

The present work is indeed suitable for reading and reviewing in a hospital bed provided a strong reading table is available. It grew from Sears-Zemansky and Wehr-Richards but incorporates many alterations from these works. In the introduction the authors claim to provide a reasonable proportion of modern physics which, after reading the book, we take to mean largely nuclear physics with some atomic physics. It is noteworthy that the word transistor does not occur in the index and indeed it is almost incumbent to refer again to this neglect of another vital branch of modern physics i.e. the study of the solid state which should include far more than an inventors' guide to semiconductor developments. Similarly magnetism has also been treated rather superficially, again a common and understandable difficulty. On the other hand, and equally surprising, the book still has a good deal of geometrical optics for what is clearly a university book. The chapters on nuclear physics, though naturally not advanced, are done very well.

The scope of the work is roughly that of an ordinary degree course or rather less and it should serve as an excellent text for general science and engineering students not in need of a buildup to advanced (real) modern physics later. The book is written with great care and illustrated lavishly and often well, and as a work of its kind and standard it can certainly be recommended highly with the above qualifications.

J. D. Craggs.

COMPLEX VARIABLE AND THE LAPLACE TRANSFORM FOR ENGINEERS

By Wilbur R. LePage

London: McGraw-Hill Publishing Co. Ltd. Pp. xvii + 475. Price 97s.

This should not be regarded as just another book on the complex variable and transform methods. The subject matter, for the most part, is certainly not new. What makes the book worthy of special comment is the way in which the material is presented. It is intended primarily for engineers who have already met the Laplace transform as a useful mathematical tool and who feel the urge to probe further into the basic theory and hence into the theory of functions of a complex variable. Strictly, the reader needs only a knowledge of the calculus but essentially the book is for the graduate.

The first chapter provides an incentive to further study by indicating how the complex numbers and the Fourier and Laplace transforms are applied to the study of linear systems. In the next few chapters the theory of functions of a complex variable is developed in such a way as to provide the background necessary for the subsequent study of integral transforms. The author aims throughout to give a reasonably rigorous treatment but with little or no pretence at a wider generality than he needs for the task in hand. It is in this sense that the book is said to be for engineers rather than for pure mathematicians. Within these limits the account is remarkably lucid and satisfying.

Introductory topics included are mapping, contour integration, infinite series, multi-valued functions and some useful theorems on real integrals, particularly improper integrals. Chapters 9 and 10 deal with the theory of the Fourier and Laplace transforms. The two-sided Laplace integral is introduced between the Fourier and one-sided Laplace integrals. After Chapter 11, which is concerned with convolution theorems, come more properties of the Laplace transform and its application to the solution of ordinary differential equations. Impulse functions are discussed in Chapter 14. The two final chapters are on periodic functions and the $\mathcal{Z}$ transform respectively.

The author uses $s = \sigma + j\omega$ throughout instead of the usual $x + iy$. The reviewer accepts his apologies to those who found this a nuisance, as he certainly did. This apart, the book is very well produced and can be strongly recommended.

J. Crank.

CHEMICAL INSTRUMENTATION—A SYSTEMATIC APPROACH TO INSTRUMENTAL ANALYSIS

By Howard A. Strobel

London: Addison-Wesley Publishing Co. Inc. Pp. xviii + 653. Price 74s.

In this book are discussed some optical and electrical methods used in chemical analysis, and a qualitative account is given of the physical laws and effects upon which the methods depend. The text is based on two one-semester courses given to advanced chemistry majors and first-year graduate students by the author, an Associate Professor of Chemistry at Duke University. The optical techniques dealt with include emission and absorption spectroscopy, refractometry and polarimetry: the electrical ones polarography, amperometric titrations, coulometry and electrogravimetry. Radioactive techniques are discussed briefly and the book ends with a set of instructions for carrying out twenty-four experiments of a physico-chemical nature.

From the point of view of the physicist, the theoretical background is treated in a superficial and elementary manner and this makes the book rather tedious. Much of the text could with advantage have been shorter—for example, the hundred pages or so devoted to an account of electronic valves and circuitry. The book is useful, however, as an introduction to the techniques described and for the many references appended to each chapter. Even so, it is expensive for its price.

J. K. Crawshaw.

PROBLEMS IN QUANTUM MECHANICS

By I. I. Goldman, V. D. Krivchenkov, V. I. Kogan and V. M. Galitskii.

Translated, edited and arranged by D. ter Haar.

London : Cleaver-Hume Press Ltd. Pp. 394. Price 42s.

It has always been accepted that one cannot learn mathematics without solving a large number of problems, and the same is true of mathematical physics. Unfortunately the problems in many books on quantum mechanics are either purely mathematical or else present extensions of the subject matter of the book, which space has prevented from incorporation in the text. The problems in this book fall into neither of these classes ; their primary aim is clearly to teach the mathematical mode of thinking which is the basis of quantum mechanics, and only secondarily do they teach facility in the use of the mathematical apparatus. This is as it should be and the book will prove to be quite invaluable to both teachers and students of physics in this country. Some of the exercises are suitable for mathematically inclined students in their second university year, but most would fit better into a final year undergraduate or a postgraduate course.

The book contains over 300 problems in non-relativistic quantum mechanics together with answers and solutions. These latter form the bulk of the book and turn, what might otherwise have been a mere collection of exercises, into a real self-educator, particularly if combined with Landau and Lifshitz's excellent volume on non-relativistic quantum mechanics, on which it is based. It is another example of the great thoroughness with which the Russians teach their university students, a thoroughness which we would do well to imitate.

The translation is excellent, but the attempt to produce the book cheaply has unfortunately led to rather unclear typography. It is hardly to be expected that such a book should be free from misprints, but a first reading did not reveal many. In future, any student who does not know his basic quantum mechanics will only have himself to blame for not working through this volume.

L. R. B. Elton.

THE FUNDAMENTAL ATOMIC CONSTANTS

By J. H. Sanders

London : Clarendon Press : Oxford University Press. Pp. vi+ 88. Price 10s.

This concise, well written and beautifully produced paper-back will be useful to undergraduates and research workers, and if the author and publishers keep it up to date with periodic new editions we shall be greatly in their debt.

Following an account of the early measurements of the atomic constants there is a complete chapter devoted to the velocity of light, which alone among these constants is accessible to direct, precise measurement. The next chapter describes the recent experiments from whose data the other atomic constants are deduced, and the final chapter shows briefly how this is done, and how the consistency of the experimental data is tested. A short appendix describes the fundamental units M, K, S, A, and there is a useful table of the " best values " as given by Cohen, DuMond, Layton and Rollett in 1955.

Dr. Sanders did not set out to write a critical review leading to a new set of best values, and he comments on the relative reliabilities of inconsistent results only where he can quote a generally accepted judgement. It is as a summary, and as a convenient source of descriptions of the recent experiments, that his book will be valued. The amalgamation of a very full bibliography with the author index is an excellent idea, which this reviewer would like to see widely adopted.

R. M. Sillitto.

SOURCE BOOK IN ASTRONOMY 1900-1950

Edited by Harlow Shapley

Massachusetts: Harvard University Press. London: Oxford University Press. Pp. xv + 423. Price 80s.

Thirty years ago, Harlow Shapley, one of the greatest of American astronomers and pioneer in the elucidation of galactic structure through researches on star-clusters, compiled with a colleague a volume of the documents marking important stages in the history of astronomy. The present volume extends the project over the first half of this century. The problem of selecting the original sources to reproduce becomes far more difficult: for the papers in this new volume constitute the basis from which controversies of to-day have sprung. But it does become possible to classify the material of the 69 papers into e.g. instruments, solar and stellar physics, variable stars, interstellar gas, evolution, relativity, etc. However it would be a mistake to regard the book as a documentary history of modern astronomy—larger size and more topics would be needed; and even now some of the extracts end just where argument would be expected to begin. That is, perhaps, the intention of the editor, to drive the reader to pursue sequels in the literature. But flash of insight into the initial situation of some contemporary problem often leaps from the page: one reads with delight the beginning of the Schmidt optics, the earliest radio-astronomy, magnetics of sunspots, the hot solar corona, rotation of stars, stellar pulsation, the first ideas as to stellar interiors, galactic rotation, etc. Shapley has never been at all egocentric, and any other editor would have included more than the two papers of his own here.

Martin Johnson.

A HISTORY OF PLATINUM

By Donald McDonald

London: Johnson Matthey & Co. Ltd. Pp. 254. Price 35s.

In view of their permanence the metals of the platinum group have long had a special place in the pursuit of the basic sciences. As a consequence they have now become indispensable materials of use in a wide range of industries.

Platinum first became an object of scientific curiosity about the middle of the eighteenth century when appreciable quantities began to reach Europe from the Spanish Colonies in South America. There followed a period of intense interest in the chemistry of the metal and in its conversion to useful and decorative forms. Its merit as an untarnishable material for telescope mirrors was quickly recognized. An industry grew in secrecy in Spain and disappeared in the Napoleonic wars. In post-revolutionary France platinum was used to prepare the standards for the newly-introduced metric system. In England at about that time, Wollaston, the discoverer of palladium, produced the fine wire for use in eyepieces which bears his name. Early in the nineteenth century important new deposits were discovered in the Urals, leading to the use in Russia for a period of platinum coinage. During this period Faraday found the metal of interest and it was he who first suggested its use as a container to preserve molten optical glass from contamination. Ultimately there grew up a large demand for platinum in the chemical industry in meeting which the author's Company played a leading part.

This eminently readable book recounts the course of scientific enquiry into platinum, its manufacture and its applications against the broad background of scientific thought of the period 1750-1880 as well as throwing some fascinating sidelights on the political canvas of the times.

G. L. J. BAILEY.

A BIBLIOGRAPHY OF DR. ROBERT HOOKE

Edited by Geoffrey Keynes

London: Clarendon Press: Oxford University Press. Pp. xix + 115. Price 50s.

Until about 25 years ago Robert Hooke might have justifiably complained that he was a seriously misunderstood person. There were many reasons no doubt for this state of affairs. As he was very poor in his younger days, " he was more given to serving other men than to pushing his own wares ", but more particularly he worked in the shadow of such geniuses as Robert Boyle, Isaac Newton and Christopher Wren, and people's eyes were blinded by their brilliance; and lastly there is no extant portrait of him which could bring and keep him literally before our eyes.

This relative obscurity exists no longer. The publication of parts of his diaries had the same effect of setting in motion a reappraisal of Robert Hooke that happened more than a century ago to his distinguished contemporary, Samuel Pepys. It was most appropriate that, in the tercentenary year of the founding of the Royal Society, the public should receive a statement as complete as possible of the known works of one who did more than any other to establish firmly the experimental bias of the " new philosophy ", which the Royal Society was required by charter to further.

In a brief biographical preface Sir Geoffrey makes the points not only that Hooke " supplied the co-ordinating intelligence which unobstrusively kept the wheels of the Society in motion ", but also that he achieved eminence as an architect and that it has " been difficult . . . to disentangle Hooke's work from Wren's, since they acted as if in partnership ". The Royal College of Physicians in Warwick Lane and the Monument, the " fish-street piller ", are the two most considerable remaining structures designed by Hooke; but as he was appointed City Surveyor after the Great Fire of London he must have been very intimately concerned in the rebuilding of the City.

The main part of this work consists of detailed bibliographical descriptions of 26 works ascribed wholly to Hooke, descriptions which in many cases include facsimile reproductions of the title pages and of selected illustrative engravings, which are of a very high standard.

There follow chapters containing similar bibliographical details about Hooke's contributions to 11 other works, and the published " Diaries ". Two appendices list, respectively, known manuscripts of Hooke's miscellaneous papers and letters, and letters from printed sources. A third appendix lists over 200 references to Biography and Criticism, and a final appendix reproduces some notes by Sir Isaac Newton on Hooke's *Micrographia*, which are contained in a manuscript in the Cambridge University Library.

D. CHILTON.

THEORY OF PROBABILITY

By William Burnside

New York: Dover Publications Inc. London: Constable & Co. Pp. 106. Price $1.00.

This small volume was first published in 1928 soon after the author's death. A R. Forsyth saw the book through the press and his notice of Burnside, written for the Royal Society, is happily included ; it is a fine tribute by one great mathematician to another.

Burnside is probably best known for his Theory of Groups, but for over thirty years he was Professor of Mathematics at the Royal Naval College at Greenwich. It is not surprising that during the first world war he should have been occupied on problems that gave him an increasing interest in mathematical probability. This book followed ; it contains a few short chapters on the calculation of probabilities, one on probabilities associated with geometrical questions, and two final chapters on the theory of errors and Gauss's law, which are devoted entirely to the basic mathematics.

The writing is clear, and the argument close and economical throughout.

J. TOPPING.

Report of the Council of The Institute of Physics and The Physical Society for the year 1960

[WITH WHICH ARE INCORPORATED REPORTS ON THE ACTIVITIES OF THE INSTITUTE AND OF THE SOCIETY IN 1960 PRIOR TO THEIR AMALGAMATION]

The first Council of the amalgamated Institute and Society was appointed as a " caretaker " one by the Board of the Institute and the Council of the Society to hold office until September 30, 1961. It met as the Council-elect in January, March and May 1960 and after the incorporation of the new body under the Companies Act, 1948, on May 17, it commenced its regular meetings, taking over the work of the Board of the Institute and the Council of the Society, which bodies ceased to exist as separate corporate entities on July 5, 1960.

For convenience and completion of the records, the activities of the Institute and of the Society before amalgamation are combined in this Report with those of the amalgamated body. For example, although in the strict legal sense the original Branches and Groups ceased to exist with the ending of the parent bodies, new ones had already been formed by the amalgamated body, so that in practice the work and activities continued uninterrupted throughout 1960. The reports on these Branch and Group activities are therefore presented here in the usual way.

The Council and its Committees

The members of the Council on December 31, 1960, were:

President: SIR JOHN COCKCROFT

Immediate Past Presidents of the Institute and of the Society: SIR GEORGE THOMSON, Mr. J. A. RATCLIFFE.

Vice-Presidents: Professor R. W. DITCHBURN, Mr. A. J. PHILPOT, Dr. W. H. TAYLOR, Dr. J. TOPPING.

Honorary Treasurer: Dr. J. TAYLOR.

Honorary Secretary: Dr. C. G. WYNNE.

Ordinary Members of the Council: Professor C. C. BUTLER, Mr. E. R. DAVIES, Professor B. H. FLOWERS, Dr. J. M. A. LENIHAN, Mr. G. R. NOAKES, Professor C. F. POWELL, Dr. F. A. VICK, Professor D. A. WRIGHT.

Chairmen of Branches: Dr. M. R. HOPKINS, Professor H. LIPSON.

Professor B. BLEANEY who was appointed to the first Council, retired on October 4, 1960, and was succeeded by Professor C. C. BUTLER.

The Council set up the undermentioned standing and executive committees, and, in accordance with Articles 54 and 57 of the amalgamated body, determined their constitutions and terms of reference.

Finance and General Purposes Committee (Chairman: Dr. J. TAYLOR, Honorary Treasurer).

Benevolent Fund Committee (Chairman: Dr. J. TAYLOR)

Membership and Education Committee (Chairman: Dr. J. TOPPING, Vice-President).

Meetings Committee (Chairman: Dr. W. H. TAYLOR, Vice-President).

Publications Committee (Chairman: Professor R. W. DITCHBURN, Vice-President).

Exhibitions Committee (Chairman: Mr. A. J. PHILPOT, Vice-President).

Representatives and nominees on Joint Committees and other bodies

The Council decided that wherever possible the representatives of the Society and of the Institute serving at the time of amalgamation should continue to represent the amalgamated body on outside Committees and Advisory Councils. In some instances the number of representatives would have been too large and an adjustment was therefore necessary. The representatives at December 31, 1960, are given in the appendix.

The establishment and incorporation of the amalgamated Institute and Society

The vast majority of the members of The Institute of Physics on the one hand and of The Physical Society on the other having indicated by their votes at the end of 1959 their desire that the two bodies should amalgamate in accordance with the Scheme submitted to them by the Board of the Institute and the Council of the Society, these two governing bodies nominated the first Council of the new body and requested it to proceed to implement the proposals outlined in the Scheme. It met as a Council-elect in January, March and May and with legal assistance completed the drafting of the Memorandum and Articles of Association and By-laws of "The Institute of Physics and The Physical Society". This draft had been prepared by a Joint Committee of the Institute and of the Society at its several meetings during the previous year. The Board of Trade, having approved the final drafts, incorporated the new body under the Companies Act, 1948, on 17 May 1960, and granted a Licence under Section 19 (1) of the Act for the omission of the word "Limited" from the name of the new body.

General Meetings of the amalgamated body and its predecessors

Extraordinary General Meeting of the amalgamated body. The first Extraordinary General Meeting of The Institute of Physics and The Physical Society was held at headquarters (47 Belgrave Square, London, S.W.1) on June 22, 1960, when the following Special Resolution was passed:

> " That the regulations contained in the document submitted to the meeting and for the purpose of identification signed by the Chairman thereof be and are hereby made the By-laws of The Institute of Physics and The Physical Society ".

Final General Meeting of The Physical Society. At an Extraordinary General Meeting of The Physical Society held on July 5, 1960, at 1 Lowther Gardens, London, after passing the Report of the Council and the Accounts for 1959, the following Special Resolutions were passed:

(i) That The Physical Society be voluntarily wound up and that Mr. Ernest William Coleman of Messrs. Knox, Cropper, Gedge & Co., Spencer House, South Place, London, E.C.2, and Dr. Alice Christine Stickland, 1 Lowther Gardens, London, S.W.7, be appointed joint liquidators for the purposes of such winding up.

(ii) That in accordance with the powers contained in Clause 8 of the Society's Memorandum of Association all surplus assets after the discharge of the Society's liabilities be transferred to The Institute of Physics and The Physical Society to form part of The Physics Trust Fund.

Final General Meeting of The Institute of Physics. An Extraordinary General Meeting of the Institute was held on Tuesday, July 5, 1960, in the Institute's House, 47 Belgrave Square, London, S.W.1. The first part of the meeting replaced the Annual General Meeting of the Institute which had orginally been convened for 5 p.m. that day. After the Annual Report of the Board and the accounts for 1959 had been adopted, the following three Special Resolutions were passed:

(i) That the Company incorporated under the Companies Act, 1948, on the 17th day of May 1960 and known as The Institute of Physics and The Physical Society, having objects similar to the objects of the Institute and prohibiting the distribution of its income and property amongst its members to an extent at least as great as imposed on the Institute by Clause 4 of its Memorandum of Association, is an institution to which the Institute may on a winding up or dissolution transfer its assets.

(ii) That upon the liquidation of the Institute proposed by the next following resolution the remaining assets of the Institute after satisfaction of all debts and liabilities be paid or distributed to The Institute of Physics and The Physical Society.

(iii) That the Institute be wound up voluntarily and that Ernest William Coleman of Messrs. Knox, Cropper, Gedge & Co., of Spencer House, South Place, E.C.2, and Herbert Raphael Lang, Secretary of The Institute of Physics of 47 Belgrave Square, London, S.W.1, be appointed liquidators for the purposes of such winding up.

Membership

It is obviously not possible to give the usual details showing changes in the register of members during the year but the following data will indicate the broad position. At the time of amalgamation The Institute of Physics had the following membership, the figures for December 31, 1959 being given also for comparison.

Table 1. *Institute membership before amalgamation*

	June '60	*Dec. '59*
Honorary Fellows and Fellows	1205	*1175*
Associates	2803	*2689*
Graduates	1552	*1526*
Students	988	*955*
Subscribers	410	*409*
Total	6958	*6754*

The Physical Society had at the same date a total membership of 2303, consisting of 1913 Fellows and Honorary Fellows and 390 Students. Of this total 812 belonged also to one of the grades of the Institute. At the end of December 1959 the Society's membership had been 1878 Fellows and 372 Students. By December 31, 1960 the membership of the amalgamated body was:

Table 2. *Institute and Society membership—December, 1960*

Honorary Fellows of The Institute of Physics and The Physical Society and Fellows of The Institute of Physics	1215
Associates of The Institute of Physics ...	2882
Graduates of The Institute of Physics... ...	1690
Total in professional grades	5787
Other Fellows of The Physical Society (not in professional grades)	1289
Students	1237
Subscribers	407
Total	8720

For some time prior to amalgamation a sub-committee of the Institute's Membership and Education Committee had been making a detailed revision of the lists of qualifications acceptable as evidence of compliance with the academic requirements for the various grades. The report of this sub-committee was approved by Council and is incorporated in the new regulations for membership (Booklet 2).

Representatives of the Membership and Examination Committee visited seven technical colleges to report on their requests for recognition for the purpose of the membership regulations relating to approved courses of study.

The Interview Panel interviewed 23 candidates.

Deaths. The Council records with regret the deaths in 1960 of:

Honorary Fellow of The Institute and Society A. F. Joffe. *Fellows of The Institute of Physics:* T. Y. Baker, G. Builder, P. R. Coursey, W. P. Davey, R. J. Davies, J. J. Dowling, Sir Arthur Fleming, D. T. Germain-

Jones, S. Marsh, H. Moore, M. Owen, J. S. Rankin, E. G. Richardson, R. K. Schofield, H. W. B. Skinner, F. J. M. Stratton, A. H. Sykes, A. E. Tattersall, H. P. Walmsley, J. West, W. J. Wiltshire. *Associates of The Institute of Physics:* R. L. Bevan, F. Blaha, E. L. Parr, H. Morton, M. B. Pinder, T. R. Prentice, R. Scott, L. Underwood, S. M. Y. Wafaquani, B. D. H. Watters, J. C. Young. *Graduate of The Institute of Physics:* C. S. Gum. *Other Fellows of The Physical Society:* Le Duc de Broglie, S. P. F. Humphreys-Owen, G. W. O. Howe, H. J. Tomlinson. *Subscriber of The Institute and Society*: E. Thomas. *Student of The Institute and Society:* A. J. McDonald.

Education

National Certificates in Applied Physics. Forty-six technical colleges presented 914 candidates for the Ordinary National Certificate in Applied Physics and 29 colleges presented 355 candidates for the Higher National Certificate. The respective numbers of candidates in 1959 were 820 and 296 and in 1958, 637 and 246. The Institute's assessors were Professor J. D. Craggs, Mr. A. E. De Barr and Dr. J. Crank for England and Wales and Dr. J. M. Valentine for Scotland. Details of the results at individual colleges were published in the December *Bulletin.*

Graduateship Examination. The number of candidates entering for the Graduateship examination has increased quite rapidly in the last few years. In 1960 193 candidates, including five taking the examination in parts, took papers other than the General Paper, compared with a total of 119 candidates in 1959 and 80 in 1958. Sixty-three candidates were successful and, of these, 27 held university degrees and 35 the Higher National Certificate in Applied Physics. Since the examination was established in 1952, 654 candidates have taken it and 199 have been successful; of the successful candidates 82 hold university degrees and 109 the Higher National Certificate in Applied Physics, while 8 hold neither of these qualifications.

Fifteen question papers were set in 1960 and the examiners were: Professor J. D. Craggs, Dr. C. A. Taylor, Mr. A. E. De Barr, Dr. A. W. Gillies, Mr. E. D. van Rest, Dr. D. Greene, Mr. M. Milbourn, Mr. R. F. Farr, Mr. J. R. Atkinson, Mr. N. Clarke and Mr. J. Yarwood. The examination papers were published in the September *Bulletin.*

The new regulations for the examination, full details of which were published early in the year, appear to have been welcomed by technical colleges. It was intended that they should first apply to the 1962 examinations but in response to requests from several colleges it was agreed that an examination for the new Part I should be held in 1961. It is expected that from 1962 the main entry for the examination will be for Part II by candidates already holding a degree or other approved qualification sufficient to give them exemption from Part I.

Postgraduate training of physicists. The Report of a joint committee set up by the Institute and Society jointly prior to amalgamation, under the chairmanship of Professor N. Kemmer, was published under the title *The postgraduate training of physicists in British universities.* It made serious criticisms of the quality of many Ph.D. physics graduates and created a good deal of interest, being referred to with approval in the scientific, educational and lay press. Copies have been widely circulated and are still requested; because of the demand the Report had to be reprinted within a few weeks.

International Conference on Physics Education. The Council of the amalgamated body confirmed the arrangements made by the Board of the Institute whereby the Deputy Secretary (Mr. N. Clarke) as Secretary of the organizing committee of the first International Conference on Physics Education was authorized to use the resources of the Institute and Society for the secretariat of the conference and for the preparation of its *Proceedings.* These have now been published. The Conference, held in Paris in July-August, was attended by a British delegation selected and supported financially by The Institute and Society. Council is gratified to be able to report that clear results of the Conference may already be seen in developments in physics education in several countries.

Arising from a recommendation of the Conference, an International Commission for Physics Education has been set up by the International Union of Pure and Applied Physics; the United Kingdom is represented by Mr. N. Clarke who is also secretary of the Commission.

Careers in physics. The Institute and Society receives, and endeavours to meet, many requests for help in providing information on careers in physics and professional education in the subject. Among ways in which this is done is the provision of speakers at school functions relating to careers. The Liverpool and North Wales Branch has also maintained a service of provision of school lectures on broader aspects of physics and this has met with considerable success.

In April the Scottish Branch, in conjunction with headquarters, took a stand at the Schoolboys and Girls Exhibition in Glasgow and this was sufficiently successful to justify the reservation of a stand at the 1961 exhibition also. Because of the increasing opportunities and demands for such work it has been decided to prepare under the guidance of the Exhibitions Committee, a number of permanent display panels that can be used on these occasions and can be lent to colleges and schools planning careers exhibitions.

Physical Society conferences

During the year the following conferences, which had been arranged by The Physical Society before its amalgamation. were held: a conference on " Classical and Quantum Turbulence " from March 21-22 in the Clarendon Laboratory, Oxford ; conferences on " Nuclear Physics " from March 30-31 in the University of Liverpool and from September 14-15 in the University of Glasgow; a conference on " Diamond physics " in the University of Reading from September 22-23.

Awards and named lectures

The 44th Guthrie Lecture was delivered by Professor

F. Hoyle on "The present relation of theory and observation in cosmology", on March 21 during the conference at Oxford. The 16th Charles Vernon Boys Prize was awarded to Professor F. Llewellyn Jones and was presented to him during the Liverpool conference when he spoke on his work on the electrical breakdown of gases and the physics of electrical contacts. The 15th Holweck Medal and Prize (awarded by the Society in conjunction with the Société Française de Physique) was awarded to Monsieur J. Brossel for his work on spectroscopy and the presentation was made to him in Oxford in May; he and the Officers of the French Society were entertained in both Oxford and Cambridge by the Officers of the Society. The 10th Rutherford Lecture on "Studies of nuclear disintegrations at very high energies" was delivered by Professor C. F. Powell during the Glasgow conference. The 37th Duddell Medal was awarded to Professor R. V. Jones for his contributions to the design of sensitive mechanical instruments and for his achievement in the growing of very large crystals; the Medal was awarded to him during the Reading conference when he lectured on his work and this was published in the *Journal of Scientific Instruments.* The Guthrie Lecture was published in the *Proceedings of The Physical Society* and the addresses given by Monsieur Brossel and by Professor Llewellyn Jones were published in the *Year Book of the Physical Society* for 1960.

Annual exhibition of scientific instruments and apparatus

The Physical Society's Exhibition of Scientific Instruments and Apparatus was held from January 18-22, 1960, in the Royal Horticultural Society's halls in London. It followed the same pattern as in previous years; there were 140 exhibitors of whom seven were representatives of the universities or hospital medical schools. The Science Museum participated, as it has for many years, and the Swiss Physical Society also participated on this occasion. The attendance was over 20,000. The Handbook issued in connexion with the Exhibition reached a total sale of 4,481 by the end of the Exhibition.

Annual craftsmanship and draughtsmanship competition

The Craftsmanship and Draughtsmanship competition held in conjunction with the Exhibition contained, as planned, two new sections: that for microwave components and that for electronic circuitry. Although there was only a small response in these sections it was agreed that their addition was well worthwhile, and it was hoped that the entries for them would increase in the future. The response to the Optical Components section was good and in the Blown Glass and Silica Ware section the standard of entries was again very high. Nine Certificates of Honourable Mention and twenty-three prizes were awarded. There was also instituted the Certificate of Merit of which fourteen were awarded; these were presented to every competitor whose entry, while not quite reaching the standard of an award, was considered worthy of display at the Exhibition. The donations from the Bowen Trust Fund and the Silvanus P. Thompson Prize Fund for the provision of some of the prizes are gratefully acknowledged.

The Council of the amalgamated Institute and Society has decided to continue this competition, but to regard it as part of its educational work. It will in the future, therefore, be dealt with by the Membership and Education Committee and not by the Exhibitions Committee, although it will continue to be held in conjunction with the annual exhibition of instruments.

Publications

After the amalgamation, the various publications of the two bodies remained unchanged in name and scope, but the editorial organizations of the two bodies were integrated during the latter part of 1960 under the supervision of Dr. A. C. Stickland (Editor and Deputy Secretary) and as a result certain minor changes were planned to take effect at the beginning of the 1961 Volumes. When allowance is made for the time of preparation and publication of papers after they are received, it will be appreciated that the data given here are largely those corresponding to the Institute and the Society as separate bodies. Table 3 gives an analysis of the material

Table 3. *Contributions submitted and published*

	Journal of Scientific Instruments		*British Journal of Applied Physics*		*Proceedings of The Physical Society*	
	1959	*1960*	*1959*	*1960*	*1959*	*1960*
Size of periodicals (text pages)*	*512*	496	*544*	556	*1814*	1983
MSS. accepted (number)	*154*	181	*86*	113	*302*	294
MSS. rejected or withdrawn	*58*	56	†	19	*54*	37
MSS. published						
Papers	*126*	124	*99*	94	*174*	179
Special articles and Conference reports	—	2	*10*	13	—	—
Laboratory and Workshop Notes	*77*	65	—	—	—	—
Research Notes	—	—	—	—	*72*	69
Letters to Editor	*12*	8	*15*	12	*25*	28

* The number of words per page of each of the two *Journals* is almost exactly twice that of the *Proceedings*.

† This figure is uncertain, but is about the same as for 1960.

received during the year compared with the corresponding information for the previous year.

The *Reports on Progress in Physics* for 1960 contained ten articles and these again were also issued as separate reprints, a convenience of which more and more advantage is being taken by readers.

The serious delays caused by the 1959 strike in the printing industry was completely overcome during the year so far as the two *Journals* were concerned but unfortunately the effects have not yet fully passed in regard to delay in publication of the *Proceedings of The Physical Society* ; every effort is being made to remove this defect in 1961.

Both the *Journal of Scientific Instruments* and the *British Journal of Applied Physics* showed small increases in their circulation and that of the *Proceedings of The Physical Society* remained about the same.

The Publications Committee set up the following Editorial Boards: for the *Proceedings of The Physical Society* and *Reports on the Progress in Physics* (Chairman: Professor M. Blackman); for the *Journal of Scientific Instruments* (Chairman: Dr. M. E. Haine); for the *British Journal of Applied Physics* (Chairman: Dr. J. M. A. Lenihan). The Committee decided also to set up a Books Sub-Committee to be responsible for all the non-periodical publications of the Institute and Society.

A revised edition of *Notes for Authors* was issued as Booklet No. 7 of the co-ordinated literature of the Institute and Society. Copies were widely distributed and it is hoped that this will assist in the continued improvement in the standard of preparation of contributions to the amalgamated body's publications.

Books. The fifth compilation from the *Journal of Scientific Instruments* by Dr. Ruth Lang under the title *Laboratory and Workshop Notes 1956-1958* was published by Edward Arnold (Publishers) Ltd. for the Institute and Society in December. The royalties from this volume are again being passed to the Benevolent Fund and thanks are due to all concerned for this contribution.

Dr. H. J. J. Braddick's small book entitled *Mechanical Design of Laboratory Apparatus*, was published in the *Monographs for Students* series by Chapman and Hall Ltd. on behalf of the Institute in June. The Books Sub-Committee has under consideration further volumes in this series.

A Physics Anthology, a selection of articles on a wide range of topics, which originally appeared in the *Bulletin*, compiled by Mr. N. Clarke, was published in June by Chapman and Hall Ltd. for The Institute of Physics.

A revised edition of *X-ray Diffraction by Polycrystalline Materials*, first published in 1955 in the *Physics in Industry* series under the technical editorship of Mr. H. S. Peiser, Mr. H. P. Rooksby and Professor A. J. C. Wilson, was published in April by Chapman and Hall Ltd for The Institute of Physics.

Catalogue of publications. Booklet No. 3 of the co-ordinated literature entitled *Publications* was issued during the year and gives full details of the Institute and Society's many publications and those issued for and on its behalf. This Booklet combines the previous separate lists issued by the Society and by the Institute.

Bulletin. The 1960 volume was completed under the title *The Institute of Physics Bulletin* but was adapted to serve the amalgamated body in the middle of the year. It consisted of 356 pages of text compared with 324 pages in 1959. The usual items—new elections, notices, etc.—were included together with 31 articles and reviews of 153 books; the 1959 volume had included 25 articles and 114 book reviews. The advertisements of vacancies for physicists, many of which related to several vacancies, totalled 511, compared with 388 in 1959; a special 16-page supplement on courses in technical colleges was issued with the May *Bulletin.*

Social Functions

The Annual Dinner of the Institute was held at the Park Lane Hotel, London, on May 3, and was attended by 327 members and guests. The President, Sir George Thomson, was in the Chair and replied to the toast " The Institute of Physics " proposed by Sir Roger Makins; the reply to " The Guests " proposed by Dr. C. Sykes was made by Mr. J. A. Ratcliffe, the President of The Physical Society.

The Annual Luncheon of Fellows of The Physical Society was as usual held during the Annual Exhibition of Scientific Instruments and Apparatus at the St. Ermin's Hotel on January 18. About 60 Fellows of the Society were present under the Chairmanship of Mr. A. J. Philpot.

Organization and co-ordination of scientific meetings

In the summer the Meetings Committee of the amalgamated body took over the work of the corresponding committees of the Institute and of the Society; all its members have served on one or other of these predecessor committees. It immediately set up a Solid State Physics Sub-Committee (Chairman: Professor F. C. Frank) and a Nuclear Physics Sub-Committee (Chairman: Professor B. H. Flowers) to continue the work of corresponding Physical Society committees in arranging meetings.

The Committee is continuing the work of the Institute's Meetings Committee towards the preparation (with the assistance of the Officers of the present Groups) of a Council policy for the Groups, including the conditions to be fulfilled before authority is granted for the formation of a new Group.

On the initiative of the respective Group Committees, Joint British Committees for Electron Microscopy and for Stress Analysis were formed to co-ordinate the activities of the various bodies in this country interested in these fields and to act as the British liaison body with the corresponding international ones. The secretariat of the former is held by The Royal Microscopical Society and the latter by The Institution of Mechanical Engineers. The Council of the Institute and Society agreed to provide the secretariat of the Joint British Committee for Vacuum Science and Technology established on the initiative of The Institute of Physics.

Professional matters

The formulation of a code of professional conduct for physicists to replace that quoted in By-law 62 was commenced by a committee under the Vice-President responsible for this area of the work (Dr. J. Topping).

The number of confidential enquiries about professional matters, some of which are by no means straightforward, received at headquarters, continues to increase. The Executive Officers, often advised by the senior Fellows of The Institute of Physics, have again been able to assist members who have consulted them about terms and conditions of service, about consulting fees, the availability of special courses, prospects for physicists at home and oversea, and part-time work for those who have retired under age limits.

Salary survey. A fifth survey of emoluments received by members of the professional grades was conducted and the report was published in the November *Bulletin.* Periodical publication of such data by The Institute of Physics has been widely welcomed and the demand for reprints of this latest report was greater than ever. Industrial employers, university authorities and Government organizations are among those who regularly ask for this information, as well as individual senior scientists in these fields of employment.

Administration, staff and housing

During the year the Council and its standing committees have been busy with the details of the necessary legal processes for the transfer of the staff and property of the separate Institute and Society to the amalgamated body. At the end of 1960 this was nearly completed. A good deal of detailed attention has also had to be given to the reorganization of the different departments consequent upon the amalgamation.

The integration of the two staffs within the framework laid down by Council took place in the autumn and only minor adjustments to the detailed scheme for implementing Council's instructions became necessary.

At some of its earliest meetings the Council-elect considered alternative schemes for housing the amalgamated body and decided that for the next few years the editorial work should be concentrated in the Society's rooms at 1 Lowther Gardens, South Kensington, under Dr. A. C. Stickland who was appointed Editor and Deputy Secretary of the amalgamated body. The Institute's house in Belgrave Square was to become the headquarters of the new body where all other activities would be concentrated including the arrangements for the sales of the publications. Dr. H. R. Lang was appointed Secretary and Mr. N. Clarke Deputy Secretary. These three Executive Officers took up their duties under the new body on July 6 having been officially released by the Society and by the Institute respectively on the previous day.

Plans for the integration and mechanization of members' records and of the despatch of circulars and publications to them were made during the year and it is hoped to have the new machinery and staff in operation in the spring of 1961.

The rapidly growing membership of the Institute and Society raises difficult problems of accommodation. The Finance and General Purposes Committee is considering ways and means of dealing with these.

The number of meetings held in the headquarters house during the year is shown in Table 4.

Table 4. *Meetings held in the headquarters house*

	1958	*1959*	*1960*
Board and Committee meetings (including Branch and Group Committees)	90	81	99
Conferences and lecture meetings...	29	30	31
Social functions	15	18	12

Co-ordinated literature

For the convenience of members and prospective members the following series of booklets was prepared and all (except No. 6 of which a pre-amalgamation edition sufficed) were issued before the end of the year : (1) General Information, (2) Membership Regulations, (3) Publications, (4) Graduateship Examination Regulations, (5) Fees and Special Rates for Publications, (6) Awards, (7) Notes for Authors.

Acknowledgements

Branch, Group and Conference Officers. The Council wishes on its own behalf and on behalf of its predecessors to record its thanks to those members who have acted as Honorary Officers of the Institute and Society's Branches, Groups and Conferences.

Meeting rooms and visits. The Council also wishes on its behalf and that of its predecessors to record its thanks to the many bodies which have generously allowed meetings of the Institute and Society and of the Branches and Groups to be held on their premises.

The Parliamentary and Scientific Committee

The Institute and Society either separately or jointly have been represented at the many meetings of this unofficial group of members of both Houses of Parliament and representatives of certain scientific and technical institutions. The Secretary (Dr. H. R. Lang) is a member of its Steering Committee. During the year the Committee was addressed by The Minister for Science (Lord Hailsham), and Dr. James Killian, Chairman of the Corporation of Massachusetts Institute of Technology. The regular discussions opened by leading authorities included " Science in industry ", and " Space research ". The Committee has been active in the matter of the serious effect the Rating and Valuation Bill was likely to have on scientific societies and on some research establishments. Several peers who are members of the Committee participated in the debate on science in the House of Lords on November 9 and parliamentary members of the Committee have asked a number of questions in Parliament on scientific matters; this has greatly assisted the work of the Committee.

Finance

Although most of the activities of the amalgamated body took place after July 5 when the Institute and Society ceased to exist as separate bodies, the accounts of the new organization cover the period since its formation earlier in the year. The allocations of the cost of headquarters and editorial services and of the Belgrave Square house and the rooms at Lowther Gardens are provisional, being based on those used previously by the Society and the Institute in their separate accounts. The accounts here presented will be submitted to the first Annual General Meeting of the amalgamated body on July 4, 1961.

Most of the income is due on January 1 in each year and much of it, such as the subscriptions to the periodicals, is payable in advance. The amalgamated body therefore received little income in 1960, as it was only formed in the middle of the year and the proportion due to it transferred from the liquidators of the Institute and the Society has been added to the accumulated reserves in the balance sheets. It is for this reason that all the accounts show a substantial deficit.

The amalgamation cost the new body and its predecessors £1,420 of which about half was for legal expenses. This amount is distributed among the appropriate items on the consolidated account. This figure does not include any charge for the considerable amount of staff time and the corresponding overhead expenses involved in carrying out this lengthy and complex task.

The accounts under the heading " The Institute of Physics and The Physical Society " are those of the organization incorporated under the Companies Act, 1948, on May 17, 1960. On July 13, at its first meeting the Council of the new organization established The Physics Trust Fund under a Trust Deed and approved its Rules. The object of this Trust Fund is to finance the educational and scientific work of the Institute and Society including the production and publication of its scientific periodicals and the meetings at all levels. It has been recognized as a charity by the Commissioners of the Inland Revenue and this has financial advantages since the parent body, having a professional clause in its constitution, does not rank as a charity. Funds are transferred from the parent body's account to the Trust Fund account to provide a contribution from the members' subscriptions towards the cost of the Trust Fund's activities. The Trust Deed provides that its accounts should be kept separately.

The Endowment Trust Fund was established by the Institute in 1945 with similar objects to the Physics Trust Fund and the Trusteeship of this fund was transferred to the new body on amalgamation. Its activities have all been transferred to the Physics Trust Fund and it is intended to integrate it with that Fund as soon as the necessary formalities can be completed.

No separate accounts for 1960 are being issued for the Society on the one hand or the Institute on the other but in due course the liquidators will in each instance present accounts showing how the funds placed in their hands by the General Meetings in July have been distributed.

Appeal. The Board of the Institute of Physics had for some time prior to the amalgamation contemplated launching an appeal to members and to industry for funds to support that part of the Institute's work concerned with the improvement of education in physics and with the dissemination of knowledge of pure and applied physics by means of meetings and otherwise. It decided however to postpone launching this appeal until the amalgamation with The Physical Society was completed. The Council of the amalgamated body, faced with the problem of financing its increasing activities, decided that one of its first actions should be the launching of this appeal and that it should aim for an increase of income during the next seven years of about £20,000 p.a. representing a gross amount of around £140,000. By the end of 1960 following a most encouraging response, particularly from industry, the total in gifts and covenanted promises amounted to £83,909. Of this, £10,393 was received in cash and in the accounts the cost of the appeal (printing, postage and temporary clerical help) of £544 has been set against that figure. The balance of £9,849 which is of course part of the Physics Trust Fund, has been used as a contribution towards the cost (estimated for 1960 at £27,000) of the 1960 educational and scientific work.

Consolidated accounts. In order to give members a simple general picture of the financial position at the end of 1960 and of the year's working, consolidated accounts are included in this Report. These combine the first half year's accounts of the Institute and Society, when they were separate, with the accounts of the amalgamated body which cover the second half of 1960. The Trust Fund accounts are also consolidated with those of the incorporated Company. It will be clear from these consolidated accounts that, having in mind the Institute and Society's many commitments, the reserves available to the Council of the new body are still in need of being substantially increased. If at any time there should be a small reduction in the income, Council would be forced, almost at once, to reduce the program of activities of the organization and to curtail the plans for expanding and improving them. As a buffer against such a contingency, Council decided to open an Expenditure Equalization Reserve with a sum of £9,500 from the surpluses on the publications and exhibition. The final surplus in the year's working is £4,138. It is not, of course, possible to compare this first year's results with a budget or with figures for the previous year, but the Council was encouraged to learn from its Finance and General Purposes Committee which has examined all the accounts in detail that the consolidated figures are not out of line with the combined original budgets for 1960 of the Society and of the Institute.

Benevolent Fund

In order to ensure that the work of the Fund would be uninterrupted by the amalgamation, the Board of the Institute at its final meeting on June 22, 1960, made appropriate modifications to the rules of the Fund and then appointed the amalgamated body as the Trustee of the Fund in place of the Institute itself.

During the year £793 was paid out for assistance in nine cases.

Under the Will of the late Mrs. Winifred Phillips, the Fund had the right of putting tenants, rent free, in her house at Welling, Kent. For some time, however, despite advertising, no suitable tenant has been found and the Committee therefore agreed to the sale of the house, the proceeds of which under the Will were paid to the Institute in January. As a result of this sale, the Trustees of the Phillips' Will have been able to pay over the bulk of the accumulated fund which had been held in reserve for the maintenance of the house. As the negotiations were protracted the incomings for both 1959 (£950) and 1960 (£650) are included in this account together with a refund of tax of £601 on the first of these payments. The total donation therefore from the Phillips' bequest in 1960 was nearly ten times the corresponding figure for the previous year. This, of course, is exceptional and non-recurrent.

During the year a further 18 members generously signed seven-year covenants to subscribe to the fund, thus enabling it to recover income tax on the sums contributed.

The Fund Committee is most grateful to all those members who sent donations or subscriptions during the year and to those who have investigated cases on its behalf or have acted as Trustees of money provided by the Committee.

While currently providing help in any deserving case, the Committee's policy continues to be " to build up its capital reserves to enable it to give adequate help if and when circumstances arise that may cause more members or their dependents to need help "—a challenge it is most anxious to be able to meet.

Branches and Groups

Annual Conference of Branch and Group Officers. The 17th Annual Consultative Conference of the Honorary Officers of the U.K. Branches and Groups of The Institute of Physics was held in the Institute's house on May 4. The President, Sir George Thomson, reported on the progress towards the last stages of the amalgamation and spoke of the work of the Council-elect under Sir John Cockcroft. Other matters discussed were the next Convention, the Benevolent Fund, the recruitment to the profession, arrangements which some Branches had made for lectures to local schools and a number of domestic matters.

The Branch and Group Officers named below were serving at December 31, 1960; their membership in all grades at that date is given and the corresponding figure for the previous year is shown in brackets :

Australian Branch: *President:* Dr. J. L. Pawsey. *Vice-President:* Professor L. G. H. Huxley. *Honorary Secretary:* Mr. A. F. A. Harper. Membership 609 (513).

The main activities of the Branch are through its Divisions. These, together with the membership and Chairman of each, are as follows:

Australian Capital Territory: Professor D. N. F. Dunbar.
New South Wales: Dr. R. E. B. Makinson.
Queensland: Dr. D. Muddlestone.
South Australia: Dr. G. de V. Gipps.
Victoria: Mr. W. C. Swinbank.
Western Australia: Dr. P. M. Jeffery.

Activities in the Divisions have included: the holding of over sixty meetings, a number of these being held conjointly with other scientific bodies; an exhibition of scientific instruments attended by more than 2500 persons (N.S.W.); the fourth " Einstein Memorial Lecture " by Sir Lawrence Bragg (S.A.); an active Solid State Physics Group (N.S.W.); and social functions in most Divisions.

Considerable attention has been given to matters relating to the training and employment of physicists ; the Victorian Division is represented on the Science and Technology Careers Bureau and has had discussions with the University Appointments Board on physics as a career, N.S.W. has made submissions to the Committee on Higher Education on the teaching of physics and S.A. has initiated a prize for physics at the School Leaving Certificate level.

The Branch is represented on various Committees as follows:

Australian National Committee on Illumination	Mr. W. R. Blevin
National Association of Testing Authorities	Dr. N. V. Lewis
Australian Journal of Physics Advisory Committee	Dr. G. H. Briggs
Australian National Committee of UNESCO for the Natural Sciences	Dr. G. H. Briggs
Conjoint Board of the College of Radiologists of Australasia and the Australian Institute of Radiography	Mr. D. J. Stevens
The Australian National Committee on Computation and Automatic Control	Dr. D. W. Posener

Malayan Branch: *Chairman:* Mr. Y. S. Hon. *Honorary Secretary-Treasurer:* Mrs. D. J. Rankin. Membership 27 (22).

The Branch had no activities of its own during the year, but members were able to attend the colloquia in the Physics Department of the University of Malaya.

Liverpool and North Wales Branch. *Chairman:* Mr. F. I. Hurley. *Honorary Secretary:* Dr. M. G. Davies. Membership 370 (324).

During the past year, eight lectures have been held in Liverpool and one in Bangor. The audience continued to average about 50.

The " Schools Scheme "—a scheme enabling lecturers from industry to visit schools and talk on the activities of various personnel in industry—has been consolidated and a booklet has been circulated to 120 schools. 26 lectures have been arranged for the session.

London and Home Counties Branch. *Chairman:* Professor A. M. Taylor. *Honorary Secretary:* Mr. D. T. R. Dighton succeeded by Mr. S. N. Ray. Membership 3539 (2809).

Three lecture meetings were held, in January, February and March. The spring visit in April was to the E.R.A. Laboratories at Leatherhead with a talk by Mr. C. G. Garton. The June visit to the Clarendon Laboratory, followed by an afternoon on the river, was attended by over 150 members and guests. In October members visited the Ewell County Technical College jointly with the College Faraday Society and heard an address by Dr. J. S. Forrest. The biennial " At Home " was held at headquarters on October 28. A symposium on " New Materials ", was held in November, when some 300 members and 50 visitors listened to six papers by specialists.

Manchester and District Branch. *Chairman:* Professor H. Lipson. *Honorary Secretary:* Dr. J. E. Geake. Membership 432 (406).

Seven evening lecture meetings were held, including one by Mr. J. G. Crowther on " The History of Science in Manchester ". A special afternoon meeting, for students only, on " Are physics students properly taught ? " was well attended and seemed to be answered " No ".

The Branch annual dinner in March was held at the Manchester College of Science and Technology. It was the best attended to date, with 86 members, wives and other guests present. The official guests were Professor and Mrs. B. H. Flowers and Dr. and Mrs. H. R. Lang.

The summer visit in July was to the Calder Hall Nuclear Power Station. 48 members made the trip, the majority by coach, and were given a talk on reactor instrumentation followed by a tour of the installation.

Midland Branch. *Chairman:* Dr. J. H. Davis succeeded by Mr. M. Milbourn. *Honorary Secretary:* Dr. W. T. Roberts. Membership 759 (642).

Nine meetings were held during the year, including visits to Joseph Lucas Ltd., the Motor Industry Research Association, A.E.I. Lamp and Lighting Co. Ltd. at Leicester and Courtaulds Ltd. at Coventry. At Easter, a joint symposium with the Education Group on " The training of the industrial physicist " was held. Professor Tolansky's lecture to the Branch on November 15 marked the twenty-fifth anniversary of its formation. The lecture was followed by a small informal dinner at the Midland Hotel, Birmingham.

The Branch annual dinner was again held in the Students Union of the University of Birmingham. The guests of honour were Mr. J. A. Ratcliffe, Dr. F. A. Vick and Mr. E. W. Warren, members of the Education Group participating in the joint symposium also attended.

North-Eastern Branch. *Chairman:* Dr. O. P. T. Kantorowicz. *Honorary Secretary:* Dr. W. D. Corner. Membership 205 (176).

The Branch held nine lecture meetings, six in Newcastle-upon-Tyne, two in Middlesbrough and one in Seascale. The Middlesbrough meetings were held jointly with the Teeside Branch of the Society of Instrument Technology and one of the Newcastle meetings jointly with the Society of Glass Technology. A particularly memorable lecture was the one which followed the Branch Annual General Meeting when Professor W. E. Curtis gave a discourse, profusely illustrated by demonstrations, on " The art of lecture demonstration ".

The summer Meeting in June consisted of a tour of the Sunderland glassworks of James A. Jobling & Co. following an interesting talk by Mr. J. F. Stirling on " The physical problems involved in the making and working of glass ".

The Branch annual dinner was held in Gateshead in March.

Scottish Branch. *Chairman:* Dr. G. A. P. Wyllie. *Honorary Secretary:* Dr. A. R. Boyle succeeded by Dr. K. H. R. Wright. Membership 319 (298).

During the course of the year 27 lectures were arranged at the various centres. They included Glasgow (11), Edinburgh (6), Aberdeen (4), Dundee (3), St. Andrews (2) and Chapelcross (1). Five of the talks held in Glasgow formed the first part of a series of lectures on " New techniques ".

In March the Branch assisted in the organization of a stand at the Schoolboys and Girls Exhibition held in the Kelvin Hall, Glasgow.

The Branch Annual General Meeting was held in May, when a large party of members visited the new Chapelcross Nuclear Power Station, near Annan, Dumfrieshire.

The Institute and Society, in association with the Scottish Education Department, held a conference in Glasgow during October to discuss " The teaching of physics with special reference to the National Certificate courses in applied physics ". The Conference was opened by an address by Dr. J. M. A. Lenihan on technical education in Scotland. A report of this meeting, drawing attention to the seriousness of the present situation was sent to the Council of the Institute and Society, which is co-operating with the Branch in endeavours to improve the situation.

South Wales Branch. *Chairman:* Dr. M. R. Hopkins. *Honorary Secretary:* Dr. H. O. Puls. Membership 297 (277).

Seven evening meetings were held, two in Newport, two in Swansea, two in Cardiff, and one in Aberystwyth. The subjects included: " The microstructure of crystalline solids ", " The physics of fully ionized gases ", " The origin of cosmic radiation ", " Some aspects of ionizing radiation in medicine ", " Modern developments in thermoelectricity ", " Problems of information and control in the visual system ", " Recent developments in the millidegree and the microdegree absolute temperature range ". In December Professor A. H. Cottrell, spoke on " The fracture of solids " to a joint meeting of the scientific societies of South Wales and Monmouthshire.

South-Western Branch. *Chairman:* Professor A. J. Woodall. *Honorary Secretary:* Dr. S. H. Ayliffe. Membership 306 (265).

Six meetings have been held, four at Bristol, one at Exeter and one at Gloucester. In addition, the Branch visited the Royal Radar Establishment, Malvern, for the summer meeting, when Dr. R. A. Smith and his staff gave short lectures and arranged demonstrations showing the work of the Physics Department. For the first time, the Branch included in its programme a Schoolchildren's Lecture for the benefit of the sixth-formers of local grammar schools. This was given on two occasions during the Easter vacation, Professor Tyndall and Professor Powell delighting some 800 schoolchildren with well-illustrated lectures.

Yorkshire Branch. *Chairman:* Dr. A. B. D. Cassie. *Honorary Secretary:* Dr. M. McCaig. Membership 297 (270).

During the year five meetings were held: Sheffield (2), Hull (1), Leeds (2). The summer meeting took the form of a visit to the Rolls-Royce altitude test plant at Derby. The Branch assisted the West RidingEducation Authority with advice for a Careers Convention.

Acoustics Group. *Chairman:* Dr. R. W. B. Stephens. *Joint Honorary Secretaries:* Dr. G. G. Parfitt and Mr. A. N. Burd. Membership 288 (282).

In 1960 the Group extended its policy of organizing symposia or groups of related lectures in preference to single lectures. It is hoped in this way that members will be able to make more profitable use of their limited time. Four symposia and four individual lectures were held, including a symposium on " Sound propagation in the atmosphere " with speakers from the U.S.A. and Denmark.

In January the Group sponsored a stand at the Physical Society's Annual Exhibition on which a number of demonstrations arranged by Group members on the theme of " Vibrations " attracted considerable interest.

The Group visit this year was to the new acoustical laboratories of AIRO Ltd., at Hemel Hempstead in May.

Applied Spectroscopy Group. *Chairman:* Dr. A. C. G. Menzies. *Honorary Secretary:* Mr. F. W. J. Garton succeeded by Dr. L. Bovey. Membership 347 (309).

Two whole-day, two half-day meetings and a two-day summer conference were held.

Two papers on " Interferometric spectroscopy " were given at a half-day February meeting and in April a whole-day symposium on " Source units for spectrochemical analysis " was held. The Summer Conference in June at Seascale in Cumberland was devoted to talks on " General aspects of spectroscopy ", and also included visits to the Windscale Works of the United Kingdom Atomic Energy Authority. A symposium on " Mass spectrometry " took place in October and Dr. Menzies gave the Chairman's Address on " Atomic absorption spectroscopy " at a half-day meeting in December.

Colour Group. *Chairman:* Mr. G. J. Chamberlin. *Honorary Secretary:* Mr. A. W. S. Tarrant. Membership 304 (291).

Six science meetings were held, of which one was a joint meeting with the Scientific and Technical Group of the Royal Photographic Society, and one a joint meeting with the Manchester Section of the Society of Dyers and Colourists. The summer visit was to the Goethean Science Foundation at Clent.

A large exhibit on " Colour adaptation " was prepared by members for the Physical Society's Exhibition, and a series of demonstrations was arranged for the "At Home" of the London and Home Counties Branch in October.

The position of the Colour Group subsequent to the amalgamation of the Institute and Society has been discussed at length in Committee, in General Meeting, and with the Officers of the Institute and Society, who indicated their willingness to assist the Committee to carry out the wishes of the majority of members of the Group. The Colour Group has always drawn a large proportion of its membership from disciplines other than physics, and the topics that it deals with range well beyond the legitimate fields of physics; it was widely felt that the Group would be better able to serve its original objects if it was reconstituted as a separate body, independent from the Institute and Society. An Extraordinary General Meeting was held on November 23, and it was resolved by a very substantial majority that this should be done.

Education Group. *Chairman:* Mr. S. W. Warren succeeded by Dr. N. Thompson. *Honorary Secretary:* Mr. T. H. Tyler succeeded by Dr. R. F. Y. Randall. Membership 604 (519).

Three lecture meetings were held at headquarters and a duplicated evening lecture-tour was made to the Mathematical Machines Laboratory at Imperial College. The Easter conference was held jointly with the Midland Branch in Birmingham on " The training of the industrial physicist ".

The summer meeting consisted of a tour of the newly opened J. J. Thomson Physics Laboratory at the University of Reading followed by a river trip to Henley.

Electronics Group. *Chairman:* Dr. T. B. Rymer. *Honorary Secretary:* Dr. C. A. Hogarth. Membership 863 (790).

During the year five well-attended lectures were given at headquarters. The Group was particularly fortunate in receiving first-hand information about various new electronic devices based on compound semiconductors, and in particular about a new photoconductive device which responds from the near infra-red out to the millimetre-wave region of the spectrum. At Easter a very well attended meeting on " Solid state microwave amplifiers " was held in the University of Nottingham in association with the Radio Spectroscopy Group and attended by 200 members and visitors.

In October a one-day meeting on " Ion sources " brought together about 50 interested participants who joined in a useful discussion. Collaboration with the Low Temperature Group proved very fruitful on November 15 when a joint meeting on " Electronic devices for helium temperatures " stretched the accommodation at headquarters to bursting point.

Electron Microscopy Group. *Chairman:* Mr. A. W. Agar. *Honorary Secretary:* Dr. R. Reed. Membership 398 (387).

In April, in the University of Leeds, the Group and the Royal Microscopical Society together had a successful conference on " The co-ordination of light and electron microscopy ".

Many Group members presented papers at the European Regional Conference, August-September, 1960, at Delft, Holland.

A well-attended one-day meeting was held in London in November, its theme being " Some physical aspects of the electron microscope ". The Group Annual General Meeting was also held on this occasion.

The Group Chairman has played an active part in the formation of the new British Joint Committee, which will co-ordinate the activities of those societies which are interested in electron microscopy.

Four *Newsletters* were circulated to members during the year.

Low Temperature Group. *Chairman:* Dr. D. H. Parkinson. *Honorary Secretary:* Dr. R. W. Powell. Membership 220 (217).

The programme has followed a similar pattern to that of recent years : a joint meeting with the Institute of Refrigeration (Mr. J. D. Gurney on " Some problems associated with the use of a high speed reciprocating compressor for aircraft cooling purposes "), two one-day symposia, one joint with the Electronics Group on

" Electronic devices at liquid helium temperatures ", the other on " Low temperature techniques " and five science meetings; Dr. Audrey U. Smith on " The effects of sub-zero temperatures on living cells, tissues and animals ", Dr. H. M. Rosenberg on " Some low temperature experiments on the alkali metals ", Dr. J. Hulbert on " Magneto-optical effects in semiconductors at low temperatures ", Dr. D. W. Moran and Dr. M. J. Pikaar on " Some new thoughts on phase equilibrium at low temperatures " and reports by members who had attended conferences in Canada and the U.S.A.

The summer visit was to the Royal Radar Establishment.

Non-Destructive Testing Group. *Chairman:* Mr. B. R. Byrne. *Honorary Secretary:* Dr. P. Lord. Membership 593 (454).

The highlights of this season's activities have been two conferences. One was held in conjunction with the Société Française de Métallurgie in London, the other with the Society of Non-Destructive Examination and the Non-Destructive Testing Society of Great Britain, in Cheltenham. Both meetings were extremely well attended.

There have been five Group lectures at headquarters. One of the more interesting ventures of the Group has been the establishment of occasional Friday morning meetings at headquarters when scientists working on subjects related to non-destructive testing have been invited to discuss their work in an entirely informal manner. These meetings produce ideas likely to influence the activities of the Group.

The Group held its Annual Dinner in January at which members and their wives had the pleasure of hearing Dr. C. A. Taylor speak on " The physics of music ".

Optical Group. *Chairman:* Mr. K. J. Habell. *Honorary Secretary:* Mr. J. W. Gates. Membership 324 (320).

Five science meetings were arranged by the Group during the year, and included papers in the fields of astronomical optics, thin films, spectroscopy, polarimetry, refractometry, fibre optics, optical design, and the instrumental design of spectrophotometers. The meeting devoted to the last mentioned topic was arranged as a joint meeting with the (independent) Photoelectric Spectrometry Group.

The Group has co-operated in the arrangements for the Conference on Optical Instruments and Techniques which is to be held in London in 1961 by the British National Committee for Optics under the auspices of the International Commission for Optics.

Stress Analysis Group. *Chairman:* Mr. A. F. C. Brown. *Honorary Secretary:* Mr. C. D. Pomeroy. Membership 254 (233).

The principal activity of the Group during the year was the Annual Conference, held during April in the University College of North Staffordshire. The emphasis of this meeting was on stresses in fibres and polymers and 14 papers on this subject were presented. Four other papers of more general interest to Group members were also given during the Conference which ended with an enjoyable visit to the British Ceramic Research Association's Laboratories at Stoke on Trent.

The number of papers submitted for presentation at the annual conference was too large for inclusion and an additional one-day meeting was held at headquarters during May, when nine papers were presented on " Experimental stress analysis ". A further meeting was held in London during October when three papers were given on " New techniques in stress analysis ". The range of topics covered during the year was extremely large and all of the meetings were well attended. Parties of members visited the D.S.I.R.'s Road Research Laboratory in February and its Building Research Station in September. At both establishments short papers were presented and tours of the appropriate parts of the laboratories were made.

X-ray Analysis Group. *Chairman:* Dr. C. W. Bunn. *Honorary Secretary:* Dr. P. T. Davies. Membership 552 (485).

A two-day conference was held in the University of Reading in April and was attended by 167 persons. The title was " The borders of X-ray analysis ", and the topics covered included micro-analysis with the electron probe, X-ray fluorescence analysis, and diffraction of electrons and neutrons. An evening meeting was held in Manchester in November on " Recent developments in optical-transform techniques ".

The Group assisted in two ways the Congress of the International Union of Crystallography, which was held in Cambridge in August. The Congress exhibition was arranged by Dr. E. J. W. Whittaker and the Equipment Sub-Committee; a list of U.K. laboratories which could accept visits from overseas members of the Congress was compiled by Dr. R. L. Gordon. The Group also prepared the U.K. section of a new edition of the *World Directory of Crystallographers* which first appeared at the Congress.

Two *News Letters* were circulated to members during the year.

APPENDIX

The Institute and Society is represented on the following committees.

The Royal Society's British National Committees

Crystallography: Dr. W. H. TAYLOR and Professor A. J. C. WILSON.

Physics: Professor R. W. DITCHBURN, Dr. H. H. HOPKINS, Dr. F. A. VICK and Professor R. WHIDDINGTON.

Scientific Radio: SIR EDWARD APPLETON and Professor SIR HARRIE MASSEY.

Space Research: Professor W. J. G. BEYNON.

Theoretical and Applied Mechanics: Professor M. W. THRING.

Other Royal Society Committees

Paul Instrument Fund Committee: Professor R. V. JONES and Dr. F. A. VICK.

Symbols Committee: Mr. J. H. AWBERY and Dr. H. T. FLINT.

Joint British Committees

Electron Microscopy: Mr. A. W. Agar and Dr. J. W. Menter.

Stress Analysis: Mr. C. D. Pomeroy.

Vacuum Science and Technology: Dr. V. E. Cosslett, Dr. T. B. Rymer, Dr. R. W. Sillars and Mr. J. Yarwood.

Radiological Units: Mr. W. Binks, Professor H. T. Flint, Mr. W. G. Marley and Professor E. A. Owen.

Non-Destructive Testing: Dr. J. Thewlis.

British Conference on Automation and Computation—Council: Dr. A. D. Booth and Mr. N. Clarke.

British Nuclear Energy Conference—Board: Dr. J. V. Dunworth, Dr. F. A. Vick and Dr. H. R. Lang.

Other Committees

Joint Committee (with The American Society for Testing Materials and The American Crystallographic Association) for Chemical Analysis by X-ray Diffraction Methods: Professor A. J. C. Wilson.

Ministry of Labour and National Service's Panel on Special Regulations for Protection against Ionizing Radiations: Mr. H. P. Rooksby and Mr. W. E. Schall.

Chemical Society—Infra Red Committee: Dr. A. C. Menzies.

Department of Scientific and Industrial Research—Standing Committee on International Institute of Refrigeration: Dr. R. W. Powell.

Faraday Society—Colloid and Biophysics Committee: Professor J. D. Bernal.

Joint Institution of Electrical Engineers—B.S.I. Committee on Electro-Medical and Radio Frequency Industrial Equipment: Dr. R. L. Smith-Rose.

International Committee on Psychometric Data: Professor P. A. Sheppard.

Ministry of Health—Radioactive Substances Advisory Committee: Professor W. E. Burcham.

Royal Astronomical Society—Geophysical Committee: Professor J. McG. Bruckshaw.

Science Masters' Association—Panel for Consideration of School Examination Syllabuses in Physics: Dr. L. R. B. Elton.

Parliamentary and Scientific Committee—General Committee: Dr. C. G. Wynne and Dr. H. R. Lang together with Dr. J. Taylor and Professor D. A. Wright at the Annual Meeting.

Science Abstracts—Committee of Management: Mr. J. H. Awbery, Mr. W. R. S. Garton, Dr. K. A. G. Mendelssohn, Dr. A. C. Stickland and Dr. L. R. G. Treloar.

National Certificates in Applied Physics

Joint Committee with the Ministry of Education: Mr. A. E. De Barr, Mr. F. I. Hurley, Dr. J. Topping and Mr. G. W. Warren.

Joint Committee with the Scottish Education Department: Mr. J. R. Atkinson, Dr. J. M. A. Lenihan and Dr. G. Morris.

Joint Committee with the Northern Ireland Ministry of Education: Dr. C. P. Black, Mr. J. A. Matthew and Dr. R. H. Sloane.

Courts of Governors

University of Exeter: Professor Sir Harrie Massey and Professor S. H. Piper.

University of Hull: Dr. E. C. Craven

Manchester College of Science and Technology: Dr. R. W. Sillars.

Governing Bodies

Brunel College of Technology: Mr. E. R. Davies.

Croydon Technical College: Mr. C. L. S. Gilford.

Kingston Technical College: Dr. G. D. Robinson.

Norwood Technical College: Dr. W. Betteridge.

Rugby College of Engineering Technology: Dr. N. F. Astbury.

Rutherford College of Technology: Mr. G. N. Peel.

South East London Technical College: Mrs. C. E. Arreger.

Welsh College of Advanced Technology, Cardiff: Dr. H. O. Puls.

Advisory Committees

Battersea College of Technology—Advisory Committee on Physics: Dr. W. F. Berg.

Birmingham College of Advanced Technology—Applied Science Advisory Committee: Mr. M. Milbourn.

Blackburn Municipal Technical College—Science Advisory Committee: Dr. A. Hargreaves.

Bournemouth Municipal College of Technology and Commerce—Science Advisory Committee: Mr. A. F. Blaylock.

Bristol College of Technology—Applied Science Advisory Committee: Dr. C. F. Sharman.

Brunel College of Technology—Advisory Panel in Physics: Dr. J. S. Forrest.

Bury Municipal Technical College—Science Advisory Committee: Dr. S. Holmes.

City and Guilds of London Institute—Advisory Committee on the Courses for Laboratory Technicians: Mr. N. Clarke, Mr. T. H. Tyler and Mr. L. Walden.

City and Guilds of London Institute—Advisory Committee on Industrial Radiography: Mr. N. Clarke, Mr. F. Y. Poynton and Mr. W. E. Schall.

City and Guilds of London Institute—Advisory Committee on the Training of Instrument Mechanics and Technicians: Mr. N. Clarke.

City and Guilds of London Institute—Exploratory Committee on Radiological Protection: Mr. H. P. Rooksby.

Croydon Technical College—Science Advisory Committee: Lt.-Col. H. S. Young.

East Anglian Regional Advisory Council for Further Education—Science Sub-Committee of the Eastern Area Technological Committee: Mr. R. G. Horner.

Ewell County Technical College—Science Advisory Committee: Dr. J. S. Forrest.

Ipswich Civic College—Council for Science: Mr. H. A. Nancarrow.

Kingston Technical College—Advisory Committee for Applied Physics: Dr. G. D. Robinson.

Lanchester College of Technology—Applied Science Advisory Committee: Dr. G. C. E. Olds.

London Regional Advisory Committee for Applied Physics and Mathematics: Mr. N. Clarke, Mr. F. Y. Poynton, Dr. R. W. B. Stephens and Mr. G. W. Warren.

Luton and South Bedfordshire College of Further Education—Science Advisory Committee: Dr. R. W. Williams.

Merseyside District Advisory Council for Further Education—Science Advisory Committee: Professor J. D. Craggs.

Monmouthshire Education Committee—Technical Education Sub-Committee: Dr. P. Hatfield.

National Council for Technological Awards—Board of Studies in Technologies other than Engineering: Dr. N. F. Astbury.

Newport and Monmouthshire College of Technology—Advisory Committee on Chemistry and Physics: Mr. C. G. Cannon.

Northampton College of Technology—Science Advisory Committee: Dr. J. T. Kendall.

Norwood Technical College—Consultative Committee for Physics: Mr. N. Clarke.

Oxford College of Technology, Art and Commerce—Science Advisory Committee: Dr. J. Thewlis.

Poole College for Further Education—Science Advisory Committee: Mr. C. F. Oxbrow.

Rutherford College of Technology—Advisory Committee for Electrical Engineering: Mr. G. N. Peel and Dr. E. E. Schneider.

Royal Technical College, Salford—Applied Science Advisory Committee: Mr. W. J. Meredith.

Salisbury and South Wilts College of Further Education—Science Advisory Committee: Mr. H. L. Green.

Slough Area Governing Body for Technical and Further Education—Science Advisory Committee: Mr. J. Yarwood.

South East London Technical College—Electrical Engineering and Applied Physics Consultative Committee: Mr. N. Clarke.

Southend-on-Sea Municipal College—Science Advisory Committee: Mr. N. Clarke.

Southern Regional Council for Further Education—Advisory Committee for Science: Mr. N. Clarke.

Regional Council for Further Education in the South West—Science Advisory Sub-Committee: Professor S. H. Piper.

Stockport College of Further Education—Science Advisory Committee: Professor H. Lipson.

Welsh Academic Board of Technology—Sub-Committee on Specialist Courses in Electrical Engineering: Mr. W. S. Vernon.

Welsh College of Advanced Technology, Cardiff—Advisory Sub-Committee for Electrical Engineering and Applied Physics: Mr. R. G. Wood.

West Ham College of Technology—Advisory Committee for Physics: Mr. L. V. Chilton.

West Midlands Advisory Council for Technical Commercial and Art Education—Advisory Panel for Applied Physics: Dr. R. E. Bastick and Mr. M. Milbourn.

Wolverhampton and Staffordshire College of Technology—Applied Science Advisory Committee: Dr. N. F. Astbury.

Yorkshire Council for Further Education—Advisory Panel for Physics: Dr. K. W. Andrews, Dr. E. C. Craven, Mr. D. A. Crooks, Dr. M. McCaig and Mr. B. O. Payne.

J. COCKCROFT, *President.*

J. TAYLOR, *Honorary Treasurer.*

C. G. WYNNE, *Honorary Secretary.*

H. R. LANG, *Secretary.*

THE INSTITUTE OF PHYSICS AND THE PHYSICAL SOCIETY

INCOME AND EXPENDITURE ACCOUNT FOR THE PERIOD 6TH JULY TO 31ST DECEMBER, 1960

	£	s.	d.
To Office and general expenses:—			
Salaries and National Insurance	5,769	19	6
Staff superannuation	39	12	9
Rent, rates, heating, cleaning, maintenance, etc. ...	1,518	0	9
Council, Committee's and Officers' travelling expenses	722	1	0
Printing and stationery	1,045	0	11
Bulletin	2,170	9	1
Postages and telephones	941	1	7
Miscellaneous expenses	816	18	8
	13,023	4	3
,, Depreciation of furniture, fittings and office machinery ...	1,206	2	6
,, Amount written off expenditure on alterations, improvements and adaptations to House	2,690	10	8
,, Leasehold Redemption Policy	985	0	0
	£17,904	17	5

	£	s.	d.	£	s.	d.
By Members' subscriptions, entrance and other fees				2,231	13	11
,, Dividends and interest, less tax				76	11	8
,, Contribution from Physics Trust Fund for alteration of premises, depreciation of furniture, fittings, office machinery and leasehold redemption policy:—						
Charged to cost of publications ...	1,627	4	4			
Charged to other work	1,627	4	4			
				3,254	8	8
,, Income tax recovered				65	16	5
,, Balance, being excess of expenditure over income carried to Reserve Fund				12,276	6	9
				£17,904	17	5

THE INSTITUTE OF PHYSICS AND THE PHYSICAL SOCIETY

BALANCE SHEET AS AT 31st DECEMBER, 1960

	£ s. d.	£ s. d.
Life Membership Fund:—		
Balance assumed from the predecessors at 6 July, 1960	6,670 5 11	
Less Transfer to Reserve Fund in respect of deceased members	63 0 0	
		6,607 5 11
Reserve Fund:—		
Balance assumed from Institute of Physics in period to 31 December, 1960	38,021 10 10	
Add Transfer from Life Membership Fund ...	63 0 0	
Sinking Fund for Leasehold Property ...	985 0 0	
	39,069 10 10	
Less Transfer from Income and Expenditure Account	12,276 6 9	
		26,793 4 1
Current Liabilities:—		
Payments received from members in advance	970 10 10	
For expenses	8,994 0 3	
		9,964 11 1
		£43,365 1 1

J. D. COCKCROFT, *President*
J. TAYLOR, *Honorary Treasurer*

	Cost £ s. d.	Depreciation £ s. d.	£ s. d.
Fixed Assets:—			
Furniture, fittings and office equipment	11,623 1 4	8,380 14 5	3,242 6 11
Alterations, improvements and adaptations of premises	10,289 8 6	7,976 19 7	2,312 8 11
	£21,912 9 10	£16,357 14 0	£5,554 15 10
Current Assets:—			
Stock on hand—stationery			862 3 5
Debtors—sundry accounts			1,391 9 4
Due from Physics Trust Fund			18,013 16 11
Subscriptions in arrears			195 16 9
Investments:—			
Quoted		4,932 0 3	
Unquoted		500 0 0	
			5,432 0 3
(*Estimated market value at 31 December, 1960 £4,866*)			
Leasehold Redemption Policy			10,835 0 0
Bank Balance and Cash in Hand			1,079 18 7
			£43,365 1 1

Report of the Auditors to the members of The Institute of Physics and The Physical Society

We have obtained all the information and explanations which to the best of our knowledge and belief were necessary for the purposes of our audit. In our opinion proper books of account have been kept by the Institute and Society so far as appears from our examination of those books, and proper returns adequate for the purposes of our audit have been received from Branches of the Institute and Society not visited by us. We have examined the above Balance Sheet and annexed Income and Expenditure Account which are in agreement with the books of the Institute and Society. In our opinion and to the best of our information and according to the explanations given to us the said accounts give the information required by the Companies Act, 1948, in the manner so required and the Balance Sheet gives a true and fair view of the state of the Institute and Society's affairs as at 31st December, 1960, and the Income and Expenditure Account gives a true and fair view of the excess of income over expenditure for the period ended on that date.

Spencer House, South Place, London, E.C.2.
28th March, 1961

KNOX, CROPPER, GEDGE & CO., *Chartered Accountants.*

THE INSTITUTE OF PHYSICS AND THE PHYSICAL SOCIETY—PHYSICS TRUST FUND

INCOME AND EXPENDITURE ACCOUNT FOR THE PERIOD 6TH JULY, 1960, TO 31ST DECEMBER, 1960

	£	s.	d.		£	s.	d.
To Graduate and National Certificate examinations ...	1,753	16	2	By Fees for examinations	93	12	6
,, Expenses of Branches and Groups	1,111	13	2	,, Donations	141	15	0
,, Conference expenses	179	7	4	,, Interest	1,376	13	9
,, Educational work, booklets and reports	406	4	9	,, Contributions to Amalgamation Appeal	9,848	12	6
,, Library	231	7	3	,, Receipts from publications including advertisements ...	12,438	10	2
,, Cost of production and distribution of publications sold ...	33,145	7	3	,, Non-members' conference fees	75	10	0
,, Proportion of overhead charges in connexion with work carried on by the Trust	10,186	15	11	,, Balance, being deficit carried to Trust Fund	24,667	2	3
,, Proportion of depreciation, alterations and Redemption Fund Account	1,627	4	4				
	£48,641	16	2		£48,641	16	2

THE INSTITUTE OF PHYSICS AND THE PHYSICAL SOCIETY—PHYSICS TRUST FUND

BALANCE SHEET AS AT 31st DECEMBER, 1960

	£	s.	d.	£	s.	d.
Physics Trust Fund:—						
Portion of Endowment Trust Fund of Institute of Physics and Accumulated Fund of Physical Society transferred within the period to 31 December, 1960	63,119	13	10			
Add Exhibition Contingency Fund	12,000	0	0			
	75,119	13	10			
Less Deficit from Income and Expenditure Account	24,667	2	3			
				50,452	11	7
Physical Society 1950 Appeal Fund				7,335	18	7
Medal and Prize Funds				6,588	2	4
Current Liabilities:—						
A.S.T.M. File Fund—X-Ray Diffraction Data File	31,083	18	5			
Low Temperature Group	2,106	9	0			
Royal Society grant	44	7	8			
Publications subscriptions in advance ...	27,591	9	0			
Printing and publishing expenses and amounts in advance	4,427	7	10			
Due to Institute of Physics and Physical Society	18,013	16	11			
				83,267	8	10
				£147,644	1	4

	£	s.	d.	£	s.	d.
Trust Fund Investments:—						
Quoted	77,880	6	1			
Unquoted	12,875	0	0			
				90,755	6	1
(Estimated market value at 31 December, 1960 £83,552)						
Stock on Hand—Publications, despatch materials and paper				9,169	9	10
Sundry Debtors				26,244	1	0
Cash:—						
Bank Deposit Account	14,050	9	11			
Bank Current Account and Cash in Hand ...	7,424	14	6			
				21,475	4	5
				£147,644	1	4

J. D. COCKCROFT, *President*
J. TAYLOR, *Honorary Treasurer*

We have audited the above Balance Sheet and have obtained all the information and explanations we have required. We have verified the Bank Balances and the Investments. In our opinion such Balance Sheet is properly drawn up so as to exhibit a true and correct view of the state of the Fund according to the best of our information and the explanations given to us and as shown by the books of the Fund.

Spencer House, South Place, London, E.C.2.
28th March, 1961

KNOX, CROPPER, GEDGE & CO., *Chartered Accountants.*

THE INSTITUTE OF PHYSICS AND THE PHYSICAL SOCIETY—ENDOWMENT TRUST FUND

BALANCE SHEET AS AT 31st DECEMBER, 1960

	£ s. d.	£ s. d.		£ s. d.
Endowment Trust Fund:—			Cash:—	
Balance as at 6 July, 1960	17,264 17 6		Balance at Lloyds Bank Ltd. on Current Account	316 14 9
Less Portion of the Fund transferred to the Physics Trust Fund within the period to 31 December, 1960	16,948 2 9	316 14 9		
J. COCKCROFT, *President.* J. TAYLOR, *Honorary Treasurer.*				
		£316 14 9		£316 14 9

We have audited the above Balance Sheet and have obtained all the information and explanations we have required. We have verified the Bank Balance. In our opinion such Balance Sheet is properly drawn up so as to exhibit a true and correct view of the state of the Fund according to the best of our information and the explanations given to us and as shown by the books of the Fund.

Spencer House, South Place, London, E.C.2.

28th March, 1961

KNOX, CROPPER, GEDGE & CO., *Chartered Accountants.*

THE INSTITUTE OF PHYSICS AND THE PHYSICAL SOCIETY

CONSOLIDATED INCOME AND EXPENDITURE ACCOUNT FOR THE YEAR 1960

	£	s.	d.
To Production and distribution of publications (excluding cost of labour and overheads)	42,321	13	1
,, Salaries, National Insurance and staff superannuation ...	36,266	1	1
,, Rent, rates, lighting, heating, cleaning, insurance and maintenance	8,205	18	2
,, Council and Committee meeting expenses and travelling expenses	1,998	11	6
,, Office expenses and stationery	5,322	6	8
,, *Bulletin* (production costs less advertising revenue) ...	2,674	10	8
,, Postages and telephones	5,983	7	8
,, Branches and Groups (including Australia)	3,378	12	5
,, Conferences and Conventions (net)	681	11	4
,, Educational work, examinations and special reports (net)	819	1	3
,, Miscellaneous expenses	4,407	11	6
,, Basic payment to Science Abstracts...	1,500	0	0
,, Exhibition costs including Handbook (excluding cost of labour and overheads)	12,462	7	5
,, Library	616	10	8
,, Decrease in Stock of Publications	1,281	13	5
	127,919	16	10
,, Amount written off expenditure on alterations, etc., to premises	2,690	10	8
,, Depreciation of furniture and fittings and office machinery	1,206	2	6
,, Leasehold Redemption Policy	985	0	0
,, Transfer to expenditure equalization account	9,500	0	0
	142,301	10	0
,, Surplus for the year carried to the Consolidated Balance Sheet	4,138	13	11
	£146,440	3	11

	£	s.	d.
By Receipts from publications (excluding advertising) ...	76,818	10	1
,, Advertising revenue	7,843	12	7
,, Members' subscriptions, entrance and application fees ...	27,149	18	2
,, Dividends and interest	3,571	3	11
,, Contributions to Amalgamation Appeal (to be set against educational and scientific work, the estimated total expenditure on which in 1960 was £27,000)	9,848	12	6
,, Exhibition receipts including Handbook	20,515	17	10
,, Miscellaneous income	692	8	10
	£146,440	3	11

THE INSTITUTE OF PHYSICS AND THE PHYSICAL SOCIETY

CONSOLIDATED BALANCE SHEET AS AT 31ST DECEMBER, 1960

	£	s.	d.	£	s.	d.
RESERVE FUNDS:—						
Balances at 1 January, 1960:						
Institute of Physics Reserve Fund	23,956	13	7			
Physical Society Accumulated Fund ...	31,478	12	4			
Endowment Trust Fund (overdrawn) ...	*1,932*	*18*	*10*			
	53,502	7	1			
Add Transfer from Life Membership Fund ...	162	0	0			
Proceeds sale 24 Park View Road (Phillips Bequest)	2,235	10	0			
Sinking Fund for leasehold property ...	985	0	0			
Exhibition Contingency Fund	12,000	0	0			
Expenditure Equalization Account ...	9,500	0	0			
Surplus from the Consolidated Income and Expenditure Account	4,138	13	11			
Balance at 31 December, 1960	£82,523	11	0			
REPRESENTED BY:—						
Assets of predecessors in hands of liquidators (before payment of liquidation expenses)	5,277	15	4			
General Reserve Fund...	26,793	4	1	26,793	4	1
Physics Trust Fund	50,452	11	7	50,452	11	7
	£82,523	11	0			
LIFE MEMBERSHIP FUND				6,607	5	11
PHYSICAL SOCIETY 1950 APPEAL FUND				7,335	18	7
MEDAL AND PRIZE FUNDS				6,588	2	4
CURRENT LIABILITIES:—						
Publications' subscriptions and members' payments in advance	28,561	19	10			
Sundry Creditors and expenses accrued ...	13,465	15	9			
A.S.T.M. File Fund—X-Ray Diffraction Data File	31,083	18	5			
Low Temperature Group—Maxwell Medal and Prize Fund	2,106	9	0			
				75,218	3	0
				£172,995	5	6

	Cost £	s.	d.	Depreciation £	s.	d.	£	s.	d.
FIXED ASSETS:—									
Furniture, fittings and equipment	11,623	1	4	8,380	14	5	3,242	6	11
Alterations, improvements and adaptations to premises	10,289	8	6	7,976	19	7	2,312	8	11
	£21,912	9	10	£16,357	14	0	£5,554	15	10
CURRENT ASSETS:—									
Stock on hand				10,031	13	3			
Sundry debtors and amounts paid in advance				27,831	7	1			
Investments at cost ... ... (*Estimated market value at 31 December, 1960, £88,418*)				96,187	6	4			
Leasehold Redemption Policy				10,835	0	0			
Bank deposit account				14,050	9	11			
Bank current account and cash in hand ...				8,504	13	1			
							167,440	9	8
							£172,995	5	6

THE INSTITUTE OF PHYSICS AND THE PHYSICAL SOCIETY—BENEVOLENT FUND

INCOME AND EXPENDITURE ACCOUNT FOR THE YEAR ENDED 31st DECEMBER, 1960

1959 £		£ s. d.	1959 £		£ s. d.
936	To Grants	793 9 0			
23	,, Expenses	7 9 6	1,383	By Subscriptions, donations and tax recovered in respect of covenants (including £2,201 gross from the executors of the Phillips Estate) ...	3,834 13 11
900	,, Balance, being excess income over expenditure carried to Capital Account	3,531 17 8	331	,, Dividends and interest	429 2 6
			145	,, Royalties on books	68 19 9
£1,859		£4,332 16 2	£1,859		£4,332 16 2

BALANCE SHEET AS AT 31st DECEMBER, 1960

1959 £		£ s. d.	£ s. d.	1959 £		£ s. d.	£ s. d.
	Capital Account:—			7,042	Fund Investments at cost ... ... (*Market value at 31 December, 1960, £8,003*)		9,004 19 5
	Balance at 1 January, 1960... ...	9,350 15 11					
9,350	*Add* Transfer from Income and Expenditure Account	3,531 17 8		21	Sundry Debtors		268 15 11
			12,882 13 7	537	Cash at Bank—Deposit Account ...	3,805 2 1	
—	Sundry Creditor		241 8 6	1,557	Current Account ...	45 4 8	
							3,850 6 9
£9,350			£13,124 2 1	£9,350			£13,124 2 1

J. TAYLOR, *Chairman of Fund Committee.*
H. R. LANG, *Secretary of the Committee.*

We have audited the above Balance Sheet and have obtained all the information and explanations we have required. We have verified the Bank Balances and the Investments. In our opinion such Balance Sheet is properly drawn up so as to exhibit a true and correct view of the state of the Fund according to the best of our information and the explanations given to us and as shown by the books of the Fund.

Spencer House, South Place, London, E.C.2.
28th March, 1961

KNOX, CROPPER, GEDGE & CO., *Chartered Accountants.*

May 1961

Manuscripts accepted for publication in the Institute and Society's periodicals

British Journal of Applied Physics

Summarized proceedings of a conference on physics of polymers–Bristol, January 1961. By D. C. Bassett.

A conference on the physics of polymers arranged by The Institute of Physics and The Physical Society was held at the H. H. Wills Physics Laboratory of the University of Bristol on January 10th–12th, 1961. The papers presented in the five sessions, devoted to Chain Statistics and Solution Properties, Molecular Motions, Crystallinity (two) and Irradiation Effects, together with an Evening Lecture by Sir Gordon Sutherland, F.R.S., are summarized in this report.

Induction furnace to attain temperatures above 3000°c in controlled atmospheres. By L. C. F. Blackman, P. H. Dundas, A. W. Moore and A. R. Ubbelohde.

An induction furnace operating at 500 kc/s is described which is capable of providing temperatures in excess of 3000°c at high vacuum or in any suitable gas mixture at pressures up to 8 atmospheres.

The work coil is mounted inside the furnace chamber, which can then be designed as a pressure vessel and constructed of electrically conducting steel. By this technique close coupling is provided between the work coil and the susceptor crucible; if desired, a heat treatment cycle to 3000°c can be completed in less than one minute. To avoid any contamination, the furnace is thermally uninsulated, so that all the heat dissipated in the crucible is lost by radiation, limiting its total surface area to about 20 cm^2 for temperatures of 3500°c with a 25 kw generator.

Application of the theory of induction heating shows that the effective resistance of the susceptor crucible can be increased by several methods, thus improving the heating efficiency of the furnace. The theory may also be applied for determining the resistivities of various susceptor materials at very high temperatures.

The use of ring-shaped neutron sources in a research reactor. By P. N. Cooper, K. Firth, and K. G. Stephens.

Measurements have been made of the effectiveness of the ring-shaped neutron sources for the Merlin reactor. The emission rate of one neutron source was measured absolutely at the National Physical Laboratory and the remaining sources were compared with this standard. A neutron to gamma ratio of $(0{\cdot}7 \pm 0{\cdot}1) \times 10^6$ n/s per curie of ^{124}Sb was obtained. The effectiveness of the sources was found by measuring the power generated in a sub-critical core. This result was in reasonable agreement with a calculation, based on two-group diffusion theory.

A method of determining the specimen–surface displacement of an x-ray diffractometer. By B. W. Delf.

A simple method of determining the specimen–surface displacement of an x-ray diffractometer specimen to an accuracy of 0·006 mm (corresponding to an angular error of $< 0{\cdot}004°2\theta$) is described. This displacement is shown to be critically dependent on the method of locking the specimen holder and on movement of the specimen-holder shaft. The effects of these two factors and methods of minimizing their effects are described.

The production of accurate gas and vapour mixtures in cylinders. By D. W. Hill.

With the increasing use of physical methods of gas and vapour analysis, there is a need for a convenient means of calibration. It is confirmed that the use of gas and vapour mixtures stored in cylinders under pressure is a suitable method. Such mixtures are stable with time. The analysis of gas and vapour mixtures has been found to agree to within one per cent of the calculated value.

The influence of the electric field on the copper whiskers growth. By T. Hofman, J. Mazur, J. Nikliborc and J. Rafalowicz.

The influence of an electric field on the growth of copper whiskers obtained by Brenner's method has been studied. There is a marked directional tendency during the growth process and it is thought that ions may play a part in the phenomenon.

INVITED ARTICLE

p–n junctions at very low temperatures. By A. K. Jonscher.

This paper gives a brief review of those low temperature properties of silicon and germanium which are relevant to the performance of p–n junctions at liquid helium temperatures. Experimental results are presented for germanium and silicon diodes and their interpretation is attempted. It is found that germanium devices behave in a manner similar to room temperature behaviour provided the ohmic contacts are adequate. Silicon diodes exhibit anomalies owing to insufficient doping of the end regions or to trapping in the base.

The matching of pierce guns to tunnels. By C. J. Milner and K. J. Ausburn.

All Pierce guns which shoot the maximum electron current through two identical apertures collinear with the axis of the gun have a unique ratio of cathode to anode radius. The value of this unique ratio is given for four important cases. A simple design procedure and relevant numerical data are given.

Calculation of the behaviour of rubber-covered pressure rollers. By G. J. Parish.

Data are given which enable the properties of nips between metal and rubber-covered pressure rollers to be calculated from the parameters of the system. The properties with which the calculation is primarily concerned are the nip width and the mean pressure in the nip, but the principle can be extended to include the peak pressure and the distribution of pressure through the nip. The calculation is based on the well-known Hertzian formula and on empirical relations which express the important effects of the rubber cover thickness.

The data refer not only to roller systems in which the loading is uniform, but also to non-uniform nips, in particular to those which show what is probably the commonest cause of non-uniformity, roller deflection.

Although the calculations refer primarily to nips between one hard roller and one relatively soft, covered, roller, they are directly applicable to nips between two identical covered rollers and may be applied, within limits, to systems in which the rollers are dissimilar in properties.

Various electrical analogues, incorporating negative resistances, for the solution of problems in elasticity. By S. C. Redshaw and K. R. Rushton.

Methods of solving many well-known problems in elasticity by means of passive resistance networks are reviewed, and the difficulties encountered when the governing partial differential equation is of the hyperbolic type are discussed.

The use of a new and very simple negative resistance, which has been incorporated into the pure resistance networks, is described and the results of several representative experiments are given.

Photosensitivity and speed of response in cadmium sulphide. By D. Shaw.

The photoconductivity and photocurrent decay time at 875 f.c. illumination have been measured for over ninety crystals of cadmium sulphide of widely different photosensitivities. The same parameters were also measured over the illumination range 0·007 to 875 foot candles for a smaller number of crystals. At 875 foot candles a clear correlation between photoconductivity and decay time was observed. The performance of all the crystals was limited by trapping. Evidence for two types of trap was obtained.

The use of a helium flush in the vacuum deposition of thin films. By G. N. Srivastava and G. D. Scott.

Silver films deposited in a vacuum chamber previously flushed with an inert gas, helium, exhibit less aggregation shown in electron micrographs and reduced ageing as determined from electrical conductivity, as compared with films produced under the usual high vacuum procedures. It is concluded that in general flushing the vacuum chamber with helium is of value in producing stable, compact and pure evaporated films.

Four-probe resistivity measurements on small circular specimens. By D. E. Vaughan.

General formulae are presented for square and linear probe arrays on circular specimens which permit the calculation of sheet resistivity from voltage and current measurements made with the probes in any position. From these formulae it is deduced that the square probe array is preferable on small specimens on the grounds of accuracy, as well as from spatial considerations.

Journal of Scientific Instruments

Device for the stabilization of helium cryostat temperatures. By C. J. Adkins.

A simple but sensitive method of detecting small changes in the level of an oil manometer is applied to the stabilization of helium cryostat temperatures. At 3°K a stability to better than 10^{-4}°K is easily obtained.

Ultra-violet absorption optical system with electronic recording for a Phywe ultracentrifuge. By J. B. T. Aten and A. Schouten.

An ultra-violet absorption optical system has been constructed for an air driven Phywé ultracentrifuge. The intensity of a parallel beam of ultraviolet light transmitted by the solution in an ultracentrifuge cell is measured by scanning the enlarged cell image with a photomultiplier. The electronic circuit permits the measurement of both transmission and optical density.

Magnetic method for the estimation of ferrite in stainless steel welds. By G. C. Curtis and J. Sherwin.

A method is described of determining, with an estimated probable error of $\pm\frac{1}{2}$, the percentage of ferrite in a stainless steel weld by measurement of the saturation intensity of magnetization of the weld. A calibration curve for 18/8/1 stainless steel is given, and is correlated with curves obtained with iron in wax specimens. There seems no reason why the range of 2 to 18% ferrite content actually measured should not be extended, using modified apparatus.

Improved fluorimeter for uranium analysis. By E. N. Haran (Herzberg).

A stable fluorimeter, easily operated and serviced, has been developed.

Drifts are reduced to a minimum by measuring only the alternating component of the fluorescent light. The exciting ultra-violet radiation is held at a constant level by a special light-stabilizing circuit. The radiation remains stable within ±1% for power line variations over the range of 200–250v. The initial warm-up is less than three minutes compared with 10–15 minutes without the light-stabilizing circuit. The sensitivity of the instrument is better than 10^{-9} gram uranium per fused pellet.

An electrical micromanometer. By H. R. Hart.
An instrument is described for measuring differential pressures in the range 10^{-4} to 1·0 in. water with high accuracy. Minimum reliable indication of 10^{-6} in. water has been attained. The instrument is null reading, but can also be used for direct recording.

The measurement of friction between rubber-like polymers and steel. By D. I. James.
A machine for measuring the coefficient of friction between a flat sheet of polymeric material and a ground steel plate is described in detail. An inverted lathe cross slide forms the basis of the drive mechanism. Frictional force is balanced against the tension developed in a spring (proof ring), the extension of which, measured with a commercial displacement pick-up, gives a direct reading of coefficient of friction. A few results are given for a PVC sample plasticized with 40% DOP. A circuit for automatic operation and recording is also described.

Method of density determination on a micro scale. By J. M. Jones.
The sample is suspended in a liquid of graded density contained within a hollow prism. This permits the determination of the refractive index of the liquid at the level of the suspended sample from which the density of the liquid and therefore of the particles may be obtained.

Production of light pulses of milli-microsecond rise time and duration by means of gas discharge tubes. By Zs. Náray and P. Varga.
Short light pulses of a rise time of $3 \cdot 10^{-9}$ second can be produced by a simple circuit arrangement containing commercially available gas discharge tubes (e.g. thyratron tubes type 2o5o, voltage stabilizer tubes type VR15o). These pulses are of sufficient intensity to be displayed directly on cathode-ray tubes by high gain photomultipliers without the use of amplifiers.

A method for gauge factor determination. By I. G. Scott.
A simple device for the determination of gauge factor of electrical resistance train gauges is described.

Proceedings of The Physical Society

Infra-red emission of electroluminescent zinc sulphide phosphors. By D. W. G. Ballentyne.
It is shown that the infra-red emission of zinc sulphide phosphors is dependent upon the copper concentration. Infra-red emission occurs after simultaneous excitation by ultra-violet and infra-red in phosphors containing less than 5×10^{-4} gm. atoms Cu/mole zinc sulphide. For greater concentrations of copper infra-red emission does not occur but such phosphors are electroluminescent.

The electrical and magnetic properties of the uranium–niobium system. By L. F. Bates and R. D. Barnard.
The magnetic susceptibilities and electrical resistivities of a series of γ-phase uranium–niobium alloys were measured over the temperature ranges 293–1200°K and 90–1200°K, respectively. The form of the resistivity–temperature–concentration relations is abnormal, especially at low temperatures and no explanation can be found in terms of localized moments on either U or Nb atoms. Comparison is made of the same properties of the γU–Mo alloys and particular attention is directed towards the electronic band structure of niobium.

Measurement of ionization and attachment coefficients in carbon monoxide in uniform fields. By M. S. Bhalla and J. D. Craggs.
Measurements of pre-breakdown currents in uniform field conditions, in carbon monoxide at different pressures, in the E/p range of 36 to 56v cm^{-1} (mm Hg)$^{-1}$ indicate the presence of electron attachment. It is suggested that the mechanism of negative ion formation is due to dissociative attachment, therefore values of α and the dimensionally equivalent attachment coefficient η have been computed from the semi-logarithmic plots of current against electrode separation, by employing the modified Townsend equation for the growth of current. Static breakdown potentials have been measured up to pd (pressure × gap length) ~1050 mm Hg cm and show that Paschen's Law is obeyed. Further, the values of secondary coefficient γ have been computed from upcurving of the semi-logarithmic plots of current against electrode separation. The values of breakdown potential calculated from the breakdown criterion are in good agreement with the measured values, showing that the static breakdown in carbon monoxide is brought about by the Townsend build up mechanism.
The mean cross sections for ionization and attachment have been calculated for various electron mean energies from the mean values of α/p and η/p obtained from the present study and compared with the values computed from low pressure single collision data, by assuming either a Maxwellian or a Druyvesteyn distribution of electron energies. It is concluded that the Maxwellian distribution is satisfactory to explain the results but the Druyvesteyn distribution does not seem to apply. Calculations show that the electron attachment observed in this study is due to resonant attachment processes occurring at about 10 ev and the contributions due to processes of a continuous nature at about 21 and 23 ev are negligible.

The Rutherford Memorial Lecture 1958. By Niels Bohr.
In connection with an account of his personal relations with Rutherford, the author gives a survey of the development initiated by the discovery of the nucleus of the atom, which proved fundamental for the gradual elucidation of the physical and chemical properties of matter.

The electronic distribution in diamond and the intensities of x-ray reflections. By H. C. Bolton and J. W. Heaton.
A theoretical calculation of the electronic charge distribution in the diamond lattice is presented. The method used is that of Thomas and Fermi and two angular terms are included to represent the departure from spherical symmetry round each carbon atom. The charge density has been used to calculate the structure factors which appear in the x-ray reflections and these calculated structure factors have been compared with recent experimental values. To some extent, both the fine details of the strong lines and the presence of the so-called ' missing reflection ' 222 are accounted for on the present theory.

The domain structure of ordered platinum–cobalt alloy. By D. J. Craik and Feliça Nuñez.
The domain structures in ordered regions of equiatomic platinum–cobalt are found to be typical of materials with high uniaxial anisotropy and low saturation magnetization. The distribution of the easy axes of discrete ordered regions within each grain confirms previous work on the nature of the ordering. The width of the domains is approximately accounted for in terms of the known properties of the material, and their behaviour in applied fields shown to resemble that of other uniaxial materials.

The ^{58}Ni(d,p)^{59}Ni and ^{60}Ni(d,p)^{61}Ni reactions. By A. W. Dalton, G. Parry, H. D. Scott and S. Swierszczewski.
In the present investigation, targets of natural nickel and isotopically pure ^{60}Ni were bombarded by deuterons with energies 8·9 MeV and 8·6 MeV respectively. From the resulting proton energy spectra a number of angular distribution measurements have been made for the ^{58}Ni(d,p)^{59}Ni and ^{60}Ni(d,p)^{61}Ni reactions and spin and parity assignments made to states of ^{59}Ni and ^{61}Ni. The results have also been compared with the gross structure peaks in the proton spectra recently reported by Schiffer, Lee and Zeidman.

The determination of m/e for free electrons by momentum transfer. By Harold A. Daw and Franklin S. Harris, Jr.
A new method for measuring m/e for free electrons has been developed by using momentum transfer. A Faraday cage mounted on a torsion device collects electrons from an electron gun. The change in maximum angular displacement of the fibre with electron beam on and off plus the measured current gave a value of m/e of $5 \cdot 82 \times 10^{-12}$ K coulomb^{-1} compared with the accepted value of $5 \cdot 6854 \times 10^{-12}$ K coulomb^{-1}.

The surface states of a simple crystal model. By T. B. Grimley and B. W. Holland.
The energies of surface states as functions of a parameter γ, which measures the electron affinity of a surface atom relative to an atom in the interior of the crystal, are calculated for a one-dimensional δ-well chain. The treatment is extended to a three-dimensional simple cubic lattice by using a modified free electron network model. Depending on γ, surface bands can exist in the energy gaps between the volume bands, or a surface band may overlap, and lose any number of states to the volume bands below it. Only the lowest volume band, derived from the single bound state of the isolated δ-well, can give rise to a surface band of lower energy.

Lines of the NV spectrum in the visible and near ultra-violet wavelength regions. By R. Hallin and T. P. Hughes.
Measured wavelengths of several NV lines emitted from SCEPTRE III are given. For hydrogenic transitions they agree closely with the predictions of a polarization formula due to Edlen. Observations of (6–7) transitions are compared with those of Lukianov and Sinitsyn which, being made at higher pressures, were probably considerably influenced by Stark effect. The possibility of using the Stark effect in high quantum-number transitions in Li-sequence atoms for density measurements is discussed briefly.

Spin–lattice relaxation time measurements in dilute potassium ferricyanide. By D. H. Paxman.
Measurements of the spin–lattice relaxation time (T_1) of $K_3Fe(CN)_6$ diluted with $K_3Co(CN)_6$ have been made in the temperature range 4·2°K to 1·6°K at x-band (9375 Mc/s). The results are compared with existing theories, and it is suggested that the Van Vleck model of phonon interaction can explain the behaviour of this material.

On resonant charge transfer in ionized dense gases. By Iovitzu Popescu.
When a feebly ionized gas is compressed until the mean distance between atoms decreases down to approximately less than ten times the atomic radius the positive charge does not move carried by the ion but rather jumps resonantly from atom to atom. This statement is reached by comparing the mean time of flight of the positive ion between two collisions with the resonant transfer time of the electron from the atom to the next positive ion.

Exchange effects and anisotropy broadening of the hyperfine spin resonance spectrum of the biphenyl negative ion in solution. By J. G. Powles and Mr. M. H. Mosley.
The electron spin resonance absorption spectrum of the biphenyl negative ion has been measured at 9·5 mm wavelength in solution in tetrahydrofuran and in diethylene glycol dimethyl ether (DGDE) over the temperature range −90°c to +70°c and for concentrations from $1 \cdot 94 \times 10^{-3}$ to $4 \cdot 35 \times 10^{-3}$ molar. The normal nine line hyperfine spectrum loses its structure with falling temperature for solution in DGDE at about −70°c independent of concentration. It is thought that this is due to a decrease in motional narrowing of an anisotropic hyperfine interaction comparable in magnitude with the isotropic hyperfine interaction. With rising temperature the

hyperfine structure again disappears. This occurs at -34°c for a concentration $4{\cdot}35 \times 10^{-3}$ molar and increases with falling concentration to $+37$°c at $1{\cdot}94 \times 10^{-3}$ molar. After loss of structure the line continues to narrow with increasing temperature. Similar but less extensive measurements have been possible for solution in tetrahydrofuran. This effect is thought to be due to exchange, i.e. perturbation of the electron spins at encounters between the radicals which are diffusing through the solvent. An analysis is carried out using a theory of Pake and Tuttle published in 1959 for which a certain quantity should be constant and of order unity. We find this quantity to be indeed of order unity over a wide range of temperature and for the two solvents but that it varies significantly nevertheless. These variations have not been explained and show that a more elaborate theory even than that of Kivelson published in 1960 is required.

Multiple proton magnetic resonance relaxation in a number of molecular liquids. By J. G. Powles and D. J. Neale.

Experimental results are given for the proton–spin lattice relaxation times T_1 at 47·5 Mc/s for liquid ethyl benzene, bromobenzene, chlorobenzene, fluorobenzene, benzene, aniline, paraxylene, mesitylene and methyl alcohol over the whole liquid range including some supercooling. Where more than one chemical type of proton is present the distinct T_1 values have been measured by a method described earlier by Powles and Neale in 1961. In ethyl benzene the ring proton T_1 has a minimum but the ethyl proton T_1 does not (as in toluene, quoted by Powles and Neale in 1961) thus emphasizing the difference in their nature. Motional correlation frequencies are deduced from the T_1 values. In ethyl benzene and aniline the substituent correlation frequency agrees with the dielectric correlation frequency. Methyl alcohol is different. The predicted ring proton correlation frequencies are lower to an extent which depends on the particular molecule and on the interpretation adopted. The results for paraxylene and mesitylene are strikingly different. The results are related to shear viscosity data. $\eta T_1/T$ should not depend on temperature, but does in a way depending on the molecule and the individual T_1. Thus the introduction of the viscosity in this way is not very helpful.

It is concluded that in these liquids composed of non-spherical molecules the thermal molecular motions are complex including motion about different axes at different rates. This complexity should be borne in mind when considering other motionally dependent properties of liquids.

The possibility of negative resistance effects in semiconductors. By B. K. Ridley and T. B. Watkins.

The possibility of obtaining negative resistance effects in a new way in semiconductors is discussed. The principle of the method is to heat carriers in a high mobility sub-band with an electric field so that they transfer when they have a high enough ‘ temperature ’ to a higher energy low mobility sub-band. The conditions required for negative resistance are discussed generally and more specific conditions are obtained for some simple cases of spherical and ellipsoidal bands by solving the Boltzmann equation. It is shown that the most favourable case is when the sub-bands are sufficiently separated in energy for the emission of optical phonons to be the dominant mechanism for energy relaxation in both sub-bands. Ge–Si alloys and some III–V compounds may have suitable sub-band structures in the conduction bands. The case of p-type uniaxially strained silicon appears to be marginal in the region where the current is proportional to the square root of the electric field. The electrical instability of a crystal with a differential negative resistance is briefly discussed and it is pointed out that some sort of ‘electrical domain’ formation may establish itself and inhibit the observation of negative resistance. Side effects which can influence the condition for negative resistance such as specimen heating, which is advantageous, and impact ionization, which is deleterious, are also discussed.

Franck–Condon factors and r–centroids for the triplet band system of CO molecule. By N. L. Singh and D. C. Jain.

It has been verified that the Morse potential function is a good approximation for the representation of the potential energy curves of $d^3\pi$ and $a^3\pi$ electronic states of CO molecule. The Franck–Condon factors for the triplet band system have been computed by the direct method of numerical integration of the Morse wave-functions. The r-centroids for this band system have been calculated by (i) the direct method of numerical integration and (ii) the quadratic equation method of Nicholls and Jarmain. A close agreement is obtained between the values of r–centroids evaluated by both the methods.

Assuming that the electronic transition moment is approximately constant, the relative population of the vibrational levels of $d^3\pi$ state of CO molecule has been calculated using Herman and Rakotoarijimy's experimental data on the relative intensity measurement of the triplet bands developed in the presence of xenon.

Elastic recovery of conical indentations. By N. A. Stilwell and D. Tabor.

This paper discusses the changes in shape which occur when a hard conical indenter is pressed into a metal (to form a plastic indentation) and then withdrawn. It is shown that there is little change in the diameter of the indentation but a decrease in its depth. This may be expressed analytically in terms of the elastic constants of the metal and there is reasonable agreement between the theoretical and observed changes in depth. The elastic energy released when the indenter is withdrawn may be calculated and it is shown that this accounts quantitatively for the elastic rebound observed when a conical indenter strikes an elasto-plastic metal. The analysis is also applied to the experimental results of Davis and Hunter published in 1960.

A note on peak displacements in X-ray diffractometry. By A. J. C. Wilson.

It is shown that at moderately high Bragg angles the shifts of the peaks of x-ray diffraction maxima resulting from geometrical aberrations of the apparatus are to a first approximation the same as those of the centroids. A second approximation to $\Delta\,(2\theta)$ is obtained by adding $Vh'''/2h''$ to the centroid shift, where V is the variance of the aberration and h'' and h''' are the second and third derivatives of the observed line profile at its maximum. Forms of the correction suitable for practical application are discussed.

The peak shifts resulting from dispersion and the Lorentz factor cancel to a first approximation. Physical aberrations, such as absorption, that multiply the line profile $I(\lambda)d\lambda$ by a factor $f(\lambda)$ depending on wavelength, shift the peak by approximately $\Delta\,(2\theta) = -2f'I \tan\theta/\lambda f I''$, where f, f', I, I'' are the values of the functions and their derivatives at the peak.

Temperature variation of optical energy gap for GaSb–InSb alloys. By J. C. Woolley and J. A. Evans.

Reasonably homogeneous, polycrystalline, solid ingots of GaSb–InSb alloys have been produced by slow directional freezing techniques, as described previously. For alloys of various compositions, normal absorption measurements have been made to determine the variation of optical energy gap E_g with temperature in the range 100–800°K. It is found that alloys show a linear variation of E_g with temperature, and values of extrapolated absolute zero energy gap and energy gap temperature coefficient are obtained. These results are compared with the data from electrical measurements described previously and the question of the variation with composition of the band form of the alloys is discussed.

LETTERS TO THE EDITOR

Detection of millimetre and sub-millimetre wave radiation by free carrier absorption in a semiconductor. By B. V. Rollin.

Consideration of exchange in ionization. By R. Peterkop.

Modulation of light by means of an electric field. By B. H. Claussen.

PUBLISHED BOOK REVIEWS

IT IS PROPOSED TO PUBLISH, APPROXIMATELY QUARTERLY, THE TITLES OF BOOKS REVIEWED IN THE INSTITUTE AND SOCIETY'S OTHER PERIODICALS.

PROCEEDINGS OF THE PHYSICAL SOCIETY

(Vol. 77, February 1, 1961)

Modern Geometrical Optics, by Max Herzberger.
Numerische Mathematik, edited by R. Sauer, E. Stiefel, J. Todd and A. Walther.
Proceedings of the First National Biophysics Conference, Colombus, Ohio, March 1957, edited by H. Quastler and H. J. Morowitz.
Beam and Wave Electronics in Microwave Tubes, by R. G. E. Hutter.
Basic Data of Plasma Physics, by Sanborn C. Brown.
Selected Lectures in Modern Physics for School Science Teachers, edited by H. Messel.
Heat and Thermodynamics, 5th edition, by J. K. Roberts and A. R. Miller.
Progress in Elementary Particle and Cosmic Ray Physics, Volume V, edited by J. G. Wilson and S. A. Wouthuysen.
Integraltafeln zur Quantenchemie, Volume IV, by H. Preuss.
Foundations of Electromagnetic Theory, by J. R. Reitz and F. J. Milford.
Correspondence of Isaac Newton, edited by H. W. Turnbull, with an introduction by E. N. da C. Andrade.
The Technique of Photomicrography, by D. F. Lawson.
Dynamical Analogies, 2nd edition, by Harry F. Olson.
Instrument Construction, No. 1, January 1959 (translated from the Russian).

(Vol. 77, March 1, 1961)

Accélérateurs de Particules et Progrès Scientifique, by N. Felici.
Kommunikation und Kybernetic in Einzeldarstellungen, Volume 1, *Grundlagen und Anwendungen der Informationstheorie*, edited by W. Meyer-Eppler.
Applications of Thermo-electricity, by H. J. Goldsmid.
Figure of Equilibrium of Celestial Bodies, by Zdenek Kopal.
Qualitätsbewertung Optischer Bilder, by E. H. Linfoot.

(Vol. 77, April 1, 1961)

Cosmology, 2nd Edition, by H. Bondi.
The Design of Physics Research Laboratories (A Symposium held by the London and Home Counties Branch of the Institute of Physics, at the Royal Institution on November 27, 1957).
The Concepts and Theories of Modern Physics, by J. B. Stallo, edited by P. W. Bridgman.
Quantitative Inorganic Analysis, 2nd edition, by R. Belcher and A. J. Nutten.
Nuclear Reactor Optimisation (Nuclear Engineering Monographs), by P. H. Margen.
The Theory of Elementary Particles, by P. Roman.
Rheology: Theory and Applications, Volume III, edited by F. R. Eirich.
L'Essai de Microdureté et ses Applications, by H. Bückle.

Introduction à l'Etude de la Rheologie by B. Persoz.

Solid State Physics, Volume X, edited by F. Seitz and D. Turnbull.

Proceedings of International Symposium on the Theory of Switching, Parts I and II.

Plasma Physics, by J. G. Linhart.

The Study of Elementary Particles by the Photographic Method, by C. F. Powell, P. H. Fowler and D. H. Perkins.

Principles of Semiconductor Device Operation, by A. K. Jonscher.

Cryophysics, Interscience Tracts on Physics and Astronomy, No. 7, by K. Mendelssohn.

Heat Transfer, Volume 2, by M. Jakob.

Physique des Circuits, par P. Grivet and R. Legros.

Plasma Physics, by S. Chandrasekhar (notes compiled by S. K. Trehan).

Approaches to Thermonuclear Power, by R. F. Saxe.

The Many Body Problem, compiled at the Université De Grenoble.

A Table of the Incomplete Elliptic Integral of the Third Kind, by R. G. Selfridge and J. E. Maxfield.

Table of the Incomplete Elliptic Integrals of the First and Third Kind, by F. A. Paxton and J. E. Rollin.

JOURNAL OF SCIENTIFIC INSTRUMENTS

(Vol. 38, February 1961)

The Cathode Ray Tube Memory of the High-speed Electronic Computer of the U.S.S.R. Academy of Sciences, by V. N. Laut and L. A. Lyubovich.

Flame Photometry, by J. A. Dean.

(Vol. 38, April 1961)

Tools of Biological Research, 2nd Series, edited by H. J. B. Atkins.

Wave Generation and Shaping, by L. Strauss.

Fundamentals of Digital Instrumentation, by D. S. Evans.

Transistor Circuit Analysis and Design, by F. C. Fitchen.

Laboratory and Workshop Notes 1956-1958, compiled and edited by Ruth Lang for The Institute of Physics.

BRITISH JOURNAL OF APPLIED PHYSICS

(Vol. 12, February 1961)

Applied Gamma-ray Spectrometry (International series of monographs on analytical chemistry, Volume 2), edited by C. E. Crouthamel.

Engineering Design with Rubber, by A. R. Payne and J. R. Scott.

Frozen Free Radicals, by G. J. Minkoff.

Graphite and its Crystal Compounds, by A. R. Ubbelohde and F. A. Lewis.

The Proton in Chemistry, by R. P. Bell.

The Nature of the Chemical Bond and the Structure of Molecules and Crystals 3rd edition, by L. Pauling.

Some Problems of Chemical Kinetics and Reactivity, Volume 2, by N. N. Semenov. Translated from the Russian by J. E. S. Bradley.

Théorie Fondamentale du Systeme Périodique des Eléments, by S. Dockx.

The Theory of Linear Viscoelasticity, by D. R. Bland.

Unsteady Motion of Continuous Media, by K. P. Stanyukovich.

X-ray Powder Photography in Inorganic Chemistry, by R. W. M. D'Eye and E. Wait.

Advances in Electronics and Electron Physics, Volume XI, edited by L. Marton.

Advances in Electronics and Electron Physics, Volume XII, *Photo-electronic Image Devices*, edited by J. D. McGee and W. L. Wilcock.

The Arc Discharge. Its Application to Power Control, by H. de B. Knight.

Computer Engineering, edited by S. A. Lebedev.

Elektronische Analogrechner, by D. Ernst.

Encyclopaedia on Cathode-Ray Oscilloscopes and Their Uses, by J. F. Rider and S. D. Uslan.

Feedback Control System Analysis and Synthesis, by J. J. D'Azzo and C. H. Houpis.

Overvoltage Research and Geophysical Applications, edited by J. R. Wait.

Conduction de la Chaleur en Régime Variable, by G. Ribaud.

Direct Conversion of Heat to Electricity, edited by J. Kaye and J. A. Welsh.

Radiation Pyrometry and its Underlying Principles of Radiant Heat Transfer, by T. R. Harrison.

Quantum Chemistry Integrals and Tables, by J. Miller, J. M. Gerhauser and F. A. Matsen.

Neutron Detection, by W. D. Allen.

Reactor Handbook, Volume I. *Materials*, 2nd revised edition, edited by C. R. Tipton.

The Study of Elementary Particles by the Photographic Method, by C. F. Powell P. H. Fowler and D. H. Perkins.

Pure and Applied Physics, Volume 9. *Nuclear Spectroscopy*. Parts A and B, edited by F. Ajzenberg-Selove.

Experimental Nuclear Physics, Volume 3, edited by E. Segrè, G. C. Hanna, M. Deutsch, O. Kofoed-Hansen and E. M. McMillan.

Atomkraft, by F. Münzinger. 3rd edition.

Nuclear Photo-disintegration, by J. S. Levinger.

The Technique of Photomicrography, by D. F. Lawson.

Space Technology, edited by H. S. Seifert.

Leichtbau. Bauelemente, Bemessungen und Konstruktionen von Flugzeugen und anderen Leichtbauwerken, by H. Hertel.

Viscoelasticity: Phenomenological Aspects, edited by J. T. Bergen.

Solid State Physics in Electronics and Telecommunications, Volumes 1, 2 and 3, edited by M. Désirant and J. L. Michiels.

Plasma Dynamics, edited by F. H. Clauser.

Structural Damping, edited by J. E. Ruzicka.

Photochemistry in the Liquid and Solid States, edited by L. J. Heidt, R. S. Livingston, E. Rabinowitch and F. Daniels.

Medical Electronics, edited by C. N. Smyth.

Immediate and Low Level Effects of Ionizing Radiations, edited by A. A. Buzzati-Traverso.

Electromagnetic Wave Propagation, edited by M. Désirant and J. L. Michiels.

Gas Chromatography Abstracts, edited by C. E. H. Knapman.

The Statistical Theory of Phase Transitions, by B. T. Geilikman. Translated from the Russian.

RADIO SPECTROSCOPY OF SOLIDS

The Institute and Society jointly with the British Radio Spectroscopy Group is arranging a conference on " Radio Spectroscopy of Solids ", in the Department of Physics of the University College of North Wales, Bangor, on September 21-22, 1961.

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DIELECTRICS RESEARCH

and in the

APPLICATION OF NEW INSULATING MATERIALS AND TECHNIQUES

are invited to apply for staff appointments carrying superannuation benefits. Housing will be made available.

Please send brief details of qualifications and any previous experience to:—

The Personnel Officer (Ref. C),
A.E.I. (Woolwich) Ltd.,
Harlow Research Laboratory,
West Road, Templefields,
Harlow, Essex.

BRISTOL COLLEGE OF SCIENCE AND TECHNOLOGY

ASHLEY DOWN, BRISTOL, 7

DEPARTMENT OF PHYSICS

The Governors invite applications for the following posts: 1. LECTURER, 2. ASSISTANT, GRADE B. Applicants should possess an Honours Degree in Physics, and have had research or industrial experience in some aspect of Applied Physics which, in the case of one post should preferably include Electronics. Teaching experience desirable. Burnham Technical Scale salaries: Lecturer: within range £1,370–£1,550 p.a. Assistant, Grade B: within range £790–£1,435 p.a. Details and application forms from the Registrar. When applying, please quote reference CST 61/14.

UNIVERSITY OF SYDNEY

CHAIR OF PHYSICS (ELECTRONIC COMPUTING)

Applications are invited for the Chair of Physics (Electronic Computing). The Professor will be in charge, under the general administration of the Head of the School of Physics, of the various branches of Electronic Computing as well as of those members of staff whose work lies mainly in this field. Salary will be at the rate of £A4,250 per annum, plus cost of living adjustments (at present £A36 p.a.). There is retirement provision under either the Sydney University Professorial Superannuation Scheme or the New South Wales State Superannuation Scheme. Under the Staff Members' Housing Scheme, in cases approved by the University and its Bankers, married men may be assisted by loans to purchase a house. The Senate reserves the right to fill the Chair by invitation. A Statement of Conditions of Appointment and Information for Candidates may be obtained from the Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1. Applications close, in Australia and London, on June 30, 1961.

THE MANCHESTER COLLEGE OF SCIENCE AND TECHNOLOGY

(Faculty of Technology in the University of Manchester)

Appointment of

LECTURER OR ASSISTANT LECTURER IN PHYSICS

Applications are invited for a Lectureship or an Assistant Lectureship in Physics in the College with corresponding title and status in the University of Manchester. The successful candidate will be required to take part in the teaching of the department which is almost entirely concerned with internal degrees of the Faculty in Physics and other subjects. He will also be allowed ample time for research under the general direction of Professor H. Lipson, the main subjects at present being X-ray diffraction, physical optics, acoustics and luminescence. Salary: Lecturer: £1,050 × £50 – £1,400 × £75 – £1,850. Assistant Lecturer: £800 × £50 – £950. Commencing salary in each case according to qualifications and experience. Superannuation under the F.S.S.U. Family allowances. Conditions of appointment and forms of application may be obtained from the Registrar, The Manchester College of Science and Technology, Manchester, 1, to whom applications must be returned by Saturday, May 27, 1961.

UNIVERSITY OF ABERDEEN NATURAL PHILOSOPHY DEPARTMENT

Applications invited for LECTURESHIPS and ASSISTANTSHIPS in EXPERIMENTAL PHYSICS, THEORETICAL PHYSICS and ELECTRONICS. Salaries: LECTURERS: £1,050 × £50 – £1,400 (Bar) × £75 – £1,850; ASSISTANTS: £800 × £50 – £950, with F.S.S.U., child allowance and part removal expenses. Initial placings according to qualifications and experience. Particulars and forms of application from the Secretary, The University, Aberdeen, with whom applications (eight copies) should be lodged by May 15, 1961. Applicants outside the British Isles may submit one copy of application.

UNIVERSITY OF QUEENSLAND

SENIOR LECTURER IN PHYSICS

Applications are invited for the abovementioned position. There are two positions available, one at Brisbane and one at University College, Townsville. Applicants must possess a Ph.D. degree in Physics from a recognized University or academic and research qualifications equivalent thereto. Applicants with previous University teaching experience will receive preference, especially for the position at Townsville. Salary: £A2,520 × £A70–£A2,870 p.a. The successful applicant will enjoy the privileges of superannuation, study leave, travel grants and other benefits available to the academic staff. Further particulars and application forms are obtainable from the Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1. Applications close, in Australia and London, on May 31, 1961.

PHYSICISTS and ELECTRICAL ENGINEERS

IMPERIAL CHEMICAL INDUSTRIES, NOBEL DIVISION, requires Physicists and Electrical Engineers for work on the application of instrumentation (including electronics) to the control and automation of their manufacturing plants. Men with an interest in transistors and other solid state devices will find ample scope for their speciality.

Conditions of employment are congenial in a large and well equipped Research and Development Department on the Ayrshire coast of the Firth of Clyde. There are unrivalled opportunities for sailing, mountaineering and golf.

The Company operates a five-day week, a Staff Pension Fund and a Profit-Sharing Scheme.

Married men will receive a refund of reasonable removal expenses and assistance towards house purchase.

Applicants should be university graduates, Members of The Institution of Electrical Engineers or The Institute of Physics and The Physical Society, or have equivalent qualifications.

Apply to: **Staff Manager,**
Imperial Chemical Industries Limited,
Nobel Division,
460 Sauchiehall Street,
Glasgow, C.2.

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THE ROYAL UNIVERSITY OF MALTA

Applications are invited for the CHAIR OF PHYSICS. Salary £1,900 p.a. (including overseas allowance). F.S.S.U. Passages provided for appointee, wife and children under 12 years on appointment and normal termination. Duties to be assumed as soon as possible. Detailed applications (eight copies) naming three referees as soon as possible to Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1, from whom further particulars may be obtained.

THE UNIVERSITY OF LEEDS DEPARTMENT OF ELECTRICAL ENGINEERING

Applications are invited for appointment to Lectureships in the Department of Electrical Engineering. The requirements fall into two categories: (1) Honours degree in Physics together with experience in the electrical engineering industry. (2) Honours degree in Electrical Engineering together with industrial or other experience in one of the following fields: electric power engineering, electrical machines, or electrical measurements. Salary on the scale £1,050 × £50 –£1,400 × £75–£1,850 (efficiency bar at £1,550), according to age, qualifications and experience. Applications (three copies) together with the names of three referees should reach The Registrar, The University, Leeds, 2 (from whom further particulars may be obtained) not later than May 22, 1961.

UNIVERSITY OF SYDNEY CHAIR OF PHYSICS (HIGH ENERGY NUCLEAR PHYSICS)

Applications are invited for the Chair of Physics (High Energy Nuclear Physics). The Professor will be in charge, under the general administration of the Head of the School of Physics, of the various branches of High Energy Nuclear Physics, as well as of those members of staff whose work lies mainly in this field. Salary will be at the rate of £A4,250 per annum, plus cost of living adjustments (at present £A36 p.a.). There is retirement provision under either the Sydney University Professorial Superannuation Scheme or the New South Wales State Superannuation Scheme. Under the Staff Members' Housing Scheme, in cases approved by the University and its Bankers, married men may be assisted by loans to purchase a house. The Senate reserves the right to fill the Chair by invitation. A statement of the Conditions of Appointment and Information for Candidates may be obtained from the Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1. Applications close, in Australia and London, on June 30, 1961.

OPERATIONAL RESEARCH

The Army Operational Research Organization require Scientific and Senior Scientific Officers and Assistant Experimental and Experimental Officers. The Organization is concerned with the application of science and scientific method to study of wide range of Army problems associated, e.g., with assessment and potentialities of weapon systems including guided missiles; development of tactics and conduct of military operations and their logistic support; communications and electronics; and problems related to Man in his military environment—his selection and training and performance as well as man/equipment relationships. Work is varied, interesting and challenging. Provided it is backed by reasonable mathematical ability, the subject in which candidate is qualified is not of major significance. Present staff embraces mathematical, physical, biological, engineering and human scientific disciplines. Of greater importance is an attitude of mind which is stimulated by problems, coupled with qualities of originality and initiative. There is no precedent to the vast majority of our problems and original research is encouraged. The major establishment at West Byfleet (Surrey) is supported by workshop and appropriate laboratory facilities, including a mathematical laboratory with electronic computer. Smaller teams exist in the War Office and at present in Germany and Singapore. Min. quals. and salary scales are as follows: SCIENTIFIC OFFICER—1st or 2nd class honours degree or equiv. Salary £738 rising by 14 annual increments to £1,222 (but promotion to Senior Scientific Officer may be expected before reaching the max. on this scale). SENIOR SCIENTIFIC OFFICER—Quals. as for Scientific Officer but min. age 26 and min. 3 years' appropriate post-grad. or other approved exp. Salary £1,342 rising by five annual increments to £1,654 with prospects of promotion to Principal Scientific Officer (£1,716 to £2,418) and above. ASSISTANT EXPERIMENTAL OFFICER—G.C.E. in five subjects including two (science and maths.) at "A" level or equiv. Salary £458 at age 18 rising by eight annual increments to £801 at 26 (or on entry over age 26) by five annual increments to £983. EXPERIMENTAL OFFICER—Quals. as for Assistant Experimental Officer, min. age 26. Salary £1,087 rising by five annual increments to £1,336. Prospect of promotion to Senior Experimental Officer (£1,508 to £1,872) and above. Due allowance made for experience when determining starting salary. Appointments pensionable under the F.S.S.U. Superannuation Scheme and successful applicants will be considered for establishment within the Scientific Civil Service under existing regulations at an early date. There are opportunities for overseas service, either on short visits or for three year tours of duty. In the latter case generous overseas allowances are payable. Application forms and specific enquiries for further information from Director of Operational Science and Research, War Office, Whitehall, S.W.1.

UNIVERSITY OF CANTERBURY
CHRISTCHURCH, NEW ZEALAND
SENIOR LECTURER OR LECTURER IN PHYSICS

Applications are invited for the abovementioned post. The successful candidate will be expected to take an active part in assisting and extending the research being carried on in the Department, namely solid state studies, radio investigations of the upper atmosphere such as meteorite distribution, auroral zone detection and studies of the lower ionosphere. It is hoped to appoint someone who is prepared to work in the field of the solid state but applications are invited from persons suitably qualified and interested in any of the research topics mentioned. The salary for a Lecturer will be at the rate of £1,250 per annum rising by annual increments of £75 to £1,700 per annum and for a Senior Lecturer at the rate of £1,750 per annum rising by annual increments to £2,000 per annum. Commencing salary will be in accordance with qualifications and experience. Approved fares to Christchurch will be allowed for an appointee, his wife and children. In addition actual removal expenses will be allowed within certain limits. Further particulars and information as to the method of application may be obtained from the Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1. Applications close, in New Zealand and London, on July 31, 1961.

IMPERIAL COLLEGE
RESEARCH ON SHOCK TUBES

Research Assistant required to work with Dr. A. G. Gaydon, F.R.S., on spectroscopic methods of temperature measurement in shock tubes. Suitable for physicist or chemist with some experience of electronics. Salary in range £800–£1,200, according to qualifications, plus F.S.S.U. and Family Allowances. Further details from Dr. Gaydon, Chemical Engineering Department, Imperial College, London, S.W.7.

COURSES

ROYAL TECHNICAL COLLEGE, SALFORD
DEPARTMENT OF PURE AND APPLIED PHYSICS
COURSE
on
" NOISE MEASUREMENT AND CONTROL "

A short course for Physicists and Engineers on " Noise Measurement and Control " will be held on Friday and Saturday, June 2 and 3, 1961. An exhibition of instruments suitable for noise and other acoustic measurements will be held concurrently. Course Fee: £3 3s. 0d. Full particulars and forms of application may be obtained from the Acting Head of Department.

BIRKBECK COLLEGE
(UNIVERSITY OF LONDON)

SESSION 1961-62 BEGINS
MONDAY, OCTOBER 2, 1961

Part-time (evening) Courses provided for Internal degrees in the Faculties of Arts and Science. Facilities also provided for full-time and part-time students reading for

- (i) Higher degrees in Arts and Science,
- (ii) M.Sc. Crystallography by examination.
- (iii) Academic postgraduate Diplomas in Psychology, Numerical Analysis and Statistics.

The Department of Scientific and Industrial Research has accepted the Postgraduate Diplomas courses in Psychology and Numerical Analysis and the M.Sc. crystallography course, as suitable for tenure of its Advanced Course Studentships. Students intending to read for Higher Degrees in Science by thesis are invited to enquire of the College whether it has available any D.S.I.R. Research Studentships. Applications for admission to the College should be made before June 1.

Pamphlet and form of application may be obtained from **The Registrar, Birkbeck College, Malet Street, W.C.1.**

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